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New York Railroad Commission.

REPORT ON TESTS
OF
STREET CAR BRAKES.

1899.

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New York (State) Board of railroad commissioners

REPORT OF

COMPETITIVE TESTS

OF

STREET CAR BRAKES

HELD BY THE

9754.7

Board of Railroad Commissioners

OF THE

STATE OF NEW YORK

1899

COMMISSIONERS:

ASHLEY W. COLE, FRANK M. BAKER, GEORGE W. DUNN.

JOHN S. KENYON, *Secretary.* CHARLES R. BARNES, *Electrical Expert.*

ALBANY, N. Y.:
BRANDOW PRINTING COMPANY,
DEPARTMENT PRINTERS.
1900.

REPORT OF COMPETITIVE TESTS

OF

STREET CAR BRAKES

By CHARLES R. BARNES, ELECTRICAL EXPERT.

ALBANY, *April* 4, 1900.

To the Board of Railroad Commissioners of the State of New York:

GENTLEMEN.— On January 6, 1899, your honorable Board authorized a public competitive test of brakes for street surface cars. This action was prompted by the alarming increase in the number of serious accidents happening on street roads throughout the State, which the Board believed to be due, to a large extent, to the inefficient brakes in use.

Pursuant to instructions, a notice of such test was published in the daily and technical press of the country; and, as an evidence of the widespread interest created in the subject by the publication of this notice, the following list of persons from whom communications were received is submitted:

Robert A. Judson, Boston, Mass.
Street Railway Review, Chicago, Ill.
James Wallace, Cohoes, N. Y.
W. W. Wheatley, Brooklyn, N. Y.
W. H. Sauvage, Denver, Col.
Geo. F. Brandua, Utica, N. Y.
W. J. Lewis, Montreal, Canada.
W. W. Bostwick, New York city.
John R. Chapin, Buffalo, N. Y.
P. T. Wall, New York city.
John Humphries, Brooklyn, N. Y.
P. P. Crafts, Boston, Mass.
Thomas Reilly, Newark, N. Y.
Chas. S. Osborn, Lansing, Mich.
I. Benjamins, Hoboken, N. J.
John C. Henry, New York city.

J. E. O'Donnell, Pittsburg, Penn.
General Electric Company, Schenectady, N. Y.
F. C. Hollis & Co., New York city.
H. S. House, Canandaigua, N. Y.
Columbia Car Lighting and Brake Company, New York city.
Devlin Street Car Brake Company, Memphis, Tenn.
J. G. Brill & Co., Philadelphia, Penn.
Neal Duplex Brake Company, Boston, Mass.
F. C. McKeige, New York city.
W. W. Brouse, Toronto, Canada.
Alexander Fuldman, New York city.
Kilbourne Manufacturing Company, Boston, Mass.
W. R. Mahaffy, Lima, Ohio.
Peter Rohrbach, Woodlawn, L. I.
W. S. Lombard, Brooklyn, N. Y.
Sterling Supply and Manufacturing Company, New York city.
Engineering News, New York city.
J. C. Breckenridge, Brooklyn, N. Y.
Geo. F. Fields, Great Falls, Mont.
C. C. St. Johns, New York city.
Chas. A. Sackett, New London, Conn.
W. J. Boland, New York city.
O. B. Cullison, York, Penn.
G. E. Pratt, Philadelphia, Penn.
C. A. Sheehan, New York city.
E. Chamberlain, Montclair, N. J.
A. P. Loper, Stonington, Conn.
John W. Rice, Springfield, Mass.
E. A. Davis, Detroit, Mich.
Sauvage Brake Company, New York city.
W. Scott Whitney, Glens Falls, N. Y.
Philip Bach and Bernard Schlegel, Long Island City.
Dennis McCarthy, Alliance, Neb.
Price, Darling & Co., New York city.
Standard Air Brake Company, New York city.
Hunt Air Brake Company, New Kensington, Penn.
G. P. Magann Air Brake Company, Detroit, Mich.
J. B. Payne, Smithtown, N. Y.
Lombard Hydraulic Brake Company, Boston, Mass.
Peckham Motor, Truck and Wheel Company, Kingston, N. Y.
Safety Appliance Company, Boston, Mass.
John Humphries, Brooklyn, N. Y.

Frederick K. Daggett, New York city.
Westinghouse Air Brake Company, Pittsburg, Penn.
Composite Brake Shoe Company, Boston, Mass.
R. B. Refenberick, Cleveland, Ohio.
F. W. Wood, Los Angeles, Cal.
Electric Selector and Signal Company, New York city.
Christensen Engineering Company, Milwaukee, Wis.
F. P. Squires, Holyoke, Mass.
Detroit Air Brake Company, Detroit, Mich.
Patrick Flood, Albany, N. Y.
J. E. Reyburn, Philadelphia, Penn.
Street Railway Journal, New York city.
McCollum Compound Friction Brake Company, Toronto, Canada.
Railroad Gazette, New York city.
Worcester Manufacturing Company, Worcester, Mass.
C. B. Fairchild, New York city.
Frank S. Snyder, Newburg, N. Y.
Henry Fox, Jr., Nelson, Neb.

Thereupon the following circular and blank application were sent to all persons known to be interested in the subject:

STATE OF NEW YORK:

BOARD OF RAILROAD COMMISSIONERS,
ALBANY, *March* 29, 1899.

NOTICE TO THE OWNERS OF BRAKES FOR STREET SURFACE CARS.

The Board of Railroad Commissioners of the State of New York will make a test of braking systems for street surface cars, on cars to be furnished for that purpose by the Metropolitan Street Railway Company of New York city.

Tests will be made of such braking systems offered as appear to the Commission to be practicable.

Applications to have braking system tested, and permits to equip cars for this purpose, must be made on the accompanying blank.

All applications must be accompanied by a drawing, tracing, blue print, or photograph, showing the system complete; also a full description of the same, setting forth the details of construction, application to car and method of operation.

The cars to be furnished will be eight-wheel cars with "Brill" maxim traction trucks fitted with G. E. 1,000 motors with non-suspension; driving wheels 30 inches, tread wheels 20 inches in diameter; length of car body over all, 28 feet; outside measurement of wheel base, 17 feet 6 inches. The railway company will furnish space in their carhouse and pitroom for the purpose of fitting up cars, but will not furnish any supplies, labor or machine-shop facilities. The general master mechanic of the Metropolitan Street Railway Company will designate the cars to be equipped and the carhouse at which the work shall be done.

These tests will be made in any manner the Board of Railroad Commissioners may determine. While the tests are being made, only one representative of the applicant will be allowed on the platform of the car on which the brake is operated.

All tests of braking system for stopping a car will be from signal on a basis of $\frac{ws}{d}$.

E — Equal efficiency of braking system.

W — Equal weight of car.

D — Equal distance between point at which signal is given to point of stop.

S — Equal rate of speed at time of giving signal.

The merits of braking system will be determined on the following points:

First.— Emergency stop at .... miles per hour.

Second.— Stop at .... miles per hour, without skidding wheels.

Third.— Service stop at .... miles per hour.

Fourth.— Ease of manipulation.

Fifth.— Reliability of system.

Sixth.— Operation of the system by the ordinary motorman.

Seventh.— Simplicity of system.

Eighth.— Liability of brakes operating when they should not.

Ninth.— Safety devices in case of failure on any part of the braking system.

Distinctive emergency brakes will be tested on their merits and their noninterference with the ordinary brake.

Applications for permits to compete and equip cars should be addressed to C. R. Barnes, Electrical Expert, Railroad Commission of the State of New York, Albany, N. Y., and will be received until May 2, 1899.

JOHN S. KENYON,

Secretary State Railroad Commission.

APPLICATION TO COMPETE IN BRAKE TESTS AND TO EQUIP A CAR FOR THAT PURPOSE.

The undersigned hereby applies to the Board of Railroad Commissioners of the State of New York for permission to compete in test of brakes for street surface cars to be made by your Board, and to secure favorable action on our petition make the following statements and agreements:

That ....., the owner of all the materials and apparatus which ..... propose to use in equipping a car for the purpose set forth in this application. The braking system submitted by ..... is shown and described in the accompanying description and blue print, photograph or drawing. That the system as shown and described is in use on the following street surface railroads (give the name of the roads, if any, the number of cars equipped and the date of equipment).

..... agree to comply with the following terms and conditions:

That ..... will at ..... own expense equip one of the cars of the Metropolitan Street Railway Company's underground electric system with ..... braking system as shown and described in the accompanying description and blue print, photograph or drawing. That ..... will complete this equipment and be prepared to run and operate a car within thirty (30) days from the date of permit, unless delayed in the work of equipment by causes over which ..... have no control.

That ..... will pay the expense of employment of a competent man, selected by the Metropolitan Street Railway Company, for the purpose of running the car; said employee to act as long and in such a manner as may be desired by the Board of Railroad Commissioners.

That when requested by the Board of Railroad Commissioners ..... will deliver the car to the Metropolitan Street Railway Company fully equipped with braking system complete, and the Metropolitan Street Railway Company may use said car in any manner, upon any route, and for any length of time not to exceed ninety (90) days, as directed by the Board of Railroad Commissioners.

That at ..... own expense ..... agree to remove the equipment from the car of the Metropolitan Street

Railway Company within ten (10) days from the receipt of notice to do so from the Board of Railroad Commissioners.

That ..... agree to pay all damages caused to the car, body, or trucks, by reason of putting on or taking off ..... equipment, and all damages to persons or property caused by the inefficiency of the braking appliance, without negligence of the person operating the car.

Signature.....

Address.....

Dated....., 1899.

The foregoing circular and blank were sent to the following:

Charles B. Fairchild, New York city.
John W. Rice, Springfield, Mass.
W. W. Brouse, Toronto, Canada.
H. E. Hunt, New Kensington, Penn.
Neal Duplex Company, Boston, Mass.
Jas. R. Elliott, New York city.
F. McKeige, New York city.
R. A. Parke, New York city.
P. H. Alexander, New York city.
Jas. C. McGuire, New York city.
A. J. Wood, New York city.
Walter Goodman, Memphis, Tenn.
F. P. Squire, Holyoke, Mass.
E. P. Squire, Springfield, Mass.
John Humphries, Brooklyn, N. Y.
E. Chamberlain, Montclair, N. J.
H. L. Howe, Canandaigua, N. Y.
E. A. Davis, Detroit, Mich.
N. A. Christensen, Milwaukee, Wis.
F. C. Randall, Hartford, Conn.
W. Scott Whitney, Glens Falls, N. Y.
Aladar Feldmann, New York city.
Frank W. Ingersoll, New York city.

The G. P. Magann Air Brake Company, Detroit, Mich.
John C. Henry, Denver, Col.
H. N. Daggett, Roxbury, Mass.
Geo. F. Field, Great Falls, Mont.
Jonas B. Payne, Smithtown, N. Y.
C. C. St. Johns, New York city.
Detroit Air Brake Company, Detroit, Mich.
C. B. Fairchild, Pittsburg, Penn.
Wm. J. Lewis, Montreal, Canada.
A. P. Loper, Stonington, Conn.
Wm. Lombard, Brooklyn, N. Y.
The General Electric Company, New York city.
Patrick Flood, Albany, N. Y.
C. A. Sheehan, New York city.
Sterling Supply and Manufacturing Company, New York city.
Bernard Schlegel, Long Island City, N. Y.
W. W. Watkins, Milwaukee, Wis.
P. I. Wall, New York city.
Peckham Motor, Truck and Wheel Company, Kingston, N. Y.
Peter Rohrbach, Woodhaven, N. Y.
J. G. Brill & Co., Philadelphia, Penn.
Davis Fresh and Salt Fish Company, Detroit, Mich.
Safety Appliance Company, Boston, Mass.
J. C. Breckenridge, Brooklyn, N. Y.
The Hunt Air Brake Company, New Kensington, Penn.
M. H. Vogel, New York city.
Dennis McCarthy, Alliance, Neb.
Charles A. Sackett, New London, Conn.
Wm. W. Whitcomb, Boston, Mass.
F. C. Hollis, New York city.

Of these, twenty-six applications, properly filled out and accompanied by blue print or tracing, and descriptions of brake, were ultimately received from the following:

Philip Bach and Bernard Schlegel.
John G. Brill & Co.
The Christensen Engineering Company.
The Columbia Electric Lighting and Brake Company.
Devlin Street Car Brake Company.
Detroit Air Brake Company.

The Electric Selector and Signal Company.
Patrick Flood.
H. L. Howe.
F. C. Hollis & Co.
The Hunt Air Brake Company.
The General Electric Company.
G. P. Magann Air Brake Company.
Lombard Hydraulic Brake Company.
Neal Duplex Brake Company.
Peckham Motor, Truck and Wheel Company.
Price, Darling & Co.
J. B. Payne.
J. E. Reyburn.
Standard Air Brake Company.
Sauvage Street Car Brake Company.
Safety Appliance Company.
F. P. Squire.
Sterling Supply and Manufacturing Company.
W. Scott Whitney.
M. H. Vogel.

These applications were carefully considered by your Board and a very liberal judgment passed upon them, only one being denied. In that case the Board did not deem the brake of sufficient merit to warrant the applicant in expending the money necessary to compete in the test, he living in the State of Nebraska. With this exception, all brakes offered were admitted to the test, though some were of doubtful merit, as the tests proved; yet, they were admitted, so that when the test was completed it could not be said that all applicants were not given an opportunity to compete. And the following permit, under date July 13, 1899, was sent to all from whom applications had been received, with the exception stated:

GENTLEMEN.— Upon the application and agreement for permission to compete in brake tests, made and filed by your company with the Board of Railroad Commissioners of the State of New York, such tests to be conducted under said Board's direction and control,

Permission is hereby given said company to equip with its braking system, described in its application and accompanying exhibits filed in the office of the Commission, one of the cars of the Metropolitan Street Railway Company (underground electric system) and to compete in trials when held.

The work of equipping a car to be done at a time and place to be designated by Thomas Millen, master mechanic of the Metropolitan Street Railway Company, 106 West Fifty-first street, New York city.

JOHN S. KENYON,
Secretary.

Notwithstanding the publicity given the test, and the notice that applications would be received only until May 2, 1899, applications from the following were received several months later:

James Wallace, Cohoes, N. Y.
Geo. F. Brandau, Utica, N. Y.
Thomas Reilly, Newark, N. J.
James Benjamin, Hoboken, N. J.
J. C. Henry, New York city.
J. E. O'Donnell, Pittsburg, Penn.
McCollum Compound Friction Brake Company, Toronto, Canada.
Worcester Manufacturing Company, Worcester, Mass.
C. B. Fairchild, New York city.
F. S. Snyder, Newburg, N. Y.
Henry Fox, Jr., Nelson, Neb.

Some of the brakes described in these latter applications were of sufficient merit to entitle them to enter the test; but if a permit were granted to one, it must be granted to all, and as this would necessitate the extending of the test into the coming summer, owing to the fact that tests could only be made on a dry rail, and as the time within which the test was to have been completed had long since expired, no action was taken on these applications.

On August 19, 1899, the following letter was sent to all parties interested and to street railway officials generally:

The Board of Railroad Commissioners has made arrangements for a test of brakes for street surface cars. Twenty-two permits have been issued for that purpose, and each person or company receiving a permit is allowed to equip with brakes one of the cars of the Metropolitan Street Railway Company, and the tests will be made, three or four on one day, at Lenox avenue and One Hundred and Forty-sixth street, New York city. The first series of tests will take place on Tuesday, August 29th, and Wednesday, August 30th, between the hours of 9 a. m. and 5 p. m. On these days from five to seven brakes will be tested. Notice of the dates of tests to follow will be given in the daily newspapers and in the street railway publications.

An invitation to be present is extended to those who are interested in the operation of street surface railroads.

By the Board,

JOHN S. KENYON,
Secretary.

The preparations for this public competitive test of brakes received much attention at the hands of your Board, it being the first test of the kind ever held under official supervision. And the Board, realizing the time it would consume, the liability of accidents occurring during its progress, and the time of the Board being fully occupied by other official matters, only the increasing frequency of accidents and the serious results attending them, induced it to undertake the tests. This action was taken in the hope that it might lead to improvement of the present brakes, as well as be an incentive to the development of a brake superior to any now in use. The need of such action is evidenced by the fact that there have been 295 persons killed and 1,599 persons injured on electric roads during the past three years, as shown by the reports on file in the records of this Board. The actual occurrences, by years, were: In 1897, 80 killed, 452 injured; in 1898, 74 killed, 541 injured; in 1899, 141 killed, 606 injured.

The official statements on file show not only an increase in the

number of accidents, but also in their variety and character. A few years ago such accidents as "head-on" and "rear-end" collisions and collisions at crossings were confined entirely to steam roads. They usually result in loss of life or serious injury to passengers, and are now nearly as frequent on electric as on steam roads. The increase in number and variety is due to the greater weight of cars and equipment and to the higher speed maintained. The cars used on the Richmond (Va.) street railway, one of the first lines equipped and operated by electric power, were built by the J. G. Brill Company, with 16-foot body, 22 feet 6 inches over all. The car body weighed about 2,300 pounds; trucks, 1,200 pounds; motor, about 1,500 pounds; total, about 6,200 pounds. The motor equipment consisted of one 7½ horse power motor, with double reduction gear and a maximum speed capacity of about ten miles per hour. To-day there are electric street cars, in service on various lines, that weigh as high as 23 tons complete and have a speed capacity of over 50 miles an hour.

The whole subject of these tests received a great deal of consideration at the hands of the Board, it being the desire that when that result was made public no claim of unfair treatment and no suspicion of favoritism could possibly be charged. To attain this end, I, as your official electrical expert, assisted by Mr. W. A. Pierson, electrical engineer of the Metropolitan Street Railway Company, designed and constructed a device that automatically recorded the result of each stop, in the form of curves, which showed the number of feet that the car had run after "stop" signal had been given and the time consumed in bringing the car to a standstill. This device was built at the One Hundred and Forty-sixth street car shops of the Metropolitan Street Railway Company, without expense to the public, and consisted of the following:

A pair of wooden wheels of 24 inches diameter (with leather tires to prevent skidding), 2-inch tread and standard gauge, were keyed to a 1½-inch axle which rotated in boxes, guided in pedestals,

outside of the wheels, screwed to the body of the car; the wheels were held down on the rails by compression springs, thus insuring good traction. On the axle between the two traction wheels was held, by means of set screws, a 20-inch sprocket wheel with 70 teeth, cut for a No. 25 Ewald detachable link chain. This chain ran through the flooring of the car and was kept in tension by two idler pulleys, with tension springs, to a loose sprocket 6¼ inches in diameter, with 22 teeth, running on a 1½-inch diameter countershaft of the instrument proper inside the car. The instrument was mounted on a table, the top board of which was made of three-ply ash, 2 inches thick, 6 feet long and 18 inches wide, with another board perpendicular to it holding the paper on which the record was made. The countershaft was properly boxed near both ends, with suitable holes, grooves, etc., for lubrication. Keyed to the shaft was a friction wheel, of the cone type, which, when thrown in, engaged the hub of the small sprockets, imparting the motion of the same to the shaft. Fixed to the end of the shaft was a bevel-gear 12 inches pitch diameter, 72 teeth meshing in a smaller 3-inch pitch diameter, 18 teeth, geared at right angles to it, rotating a 1-inch steel rod, cut with a screw-thread between journal boxes near each end, the number of threads on the screw being eight to the inch and the length 4 feet 4½ inches. The friction clutch was thrown in by means of a lever 13 inches long, the clutch being 3 inches from the fulcrum towards the center. At the extreme end was attached, by means of a screw, a strong tension spring, distending when the clutch was drawn out, and held by a protected catch, the other end of which was the armature of an electro-magnet. When the circuit which included the magnet was closed, the clutch was drawn up, releasing the clutch lever, thus throwing in the clutch, and the motion of the sprocket was imparted to the screw rod through the bevel-gears. Running in guides screwed to the top of the table with a split nut, having a locking device for engaging or disengaging it from the screw, was a carriage, which, when the clutch was thrown in, travelled in the

guides until the car stopped. Knowing the ratio between the travel of the carriage and the travel of the traction wheels on the track, the distance required to stop the car was easily computed. Attached to the carriage and at right angles to the screw was a 1-inch round brass tube, slotted on each side, in which was a cylindrical 1½-pound weight of lead, with pencil attached having compression spring behind it to insure its bearing against the sheet of paper on which the record was taken. On top of the carriage was screwed a clock movement, containing a heavy main spring to secure quick action when movement was released. From the weight carrying the pencil a string was secured, running over the top of the tube on a pulley and down to a sheave held to the movement by a clutch, which could be thrown out to allow the weight to be raised, by winding the string on the sheave. The movement was released at the same time the cone clutch was thrown in, by means of a string attached to the end of the clutch lever, which pulled a lever attached to the board; this, in turn, threw out another lever which was holding the spokes of one of the wheels on the movement, thus allowing it to run, and the weight to descend into the tube at a certain rate. On the axle of the pony wheels of one of the trucks was placed a sheave which operated, within the car, a Boyer speed recorder, with a dial showing the speed of the car, in miles per hour, by means of a revolving hand. On the dial was arranged a movable contact point, which could be set at any desired speed. When the car reached the required speed the dial hand made contact with the movable point and closed the circuit in the electro-magnet, actuating the clutch and movement. When the clutch was thrown in, another circuit was automatically closed, ringing a bell on the platform of the car, and thus signalling the motorman to throw off the power and apply the brakes. To prevent the brake operator, or motorman, from taking up the slack in the brake rigging before the proper signal was given, a bell circuit was placed with the bell on the recording table. As soon as the least movement was given to the handle of the brake, the bell

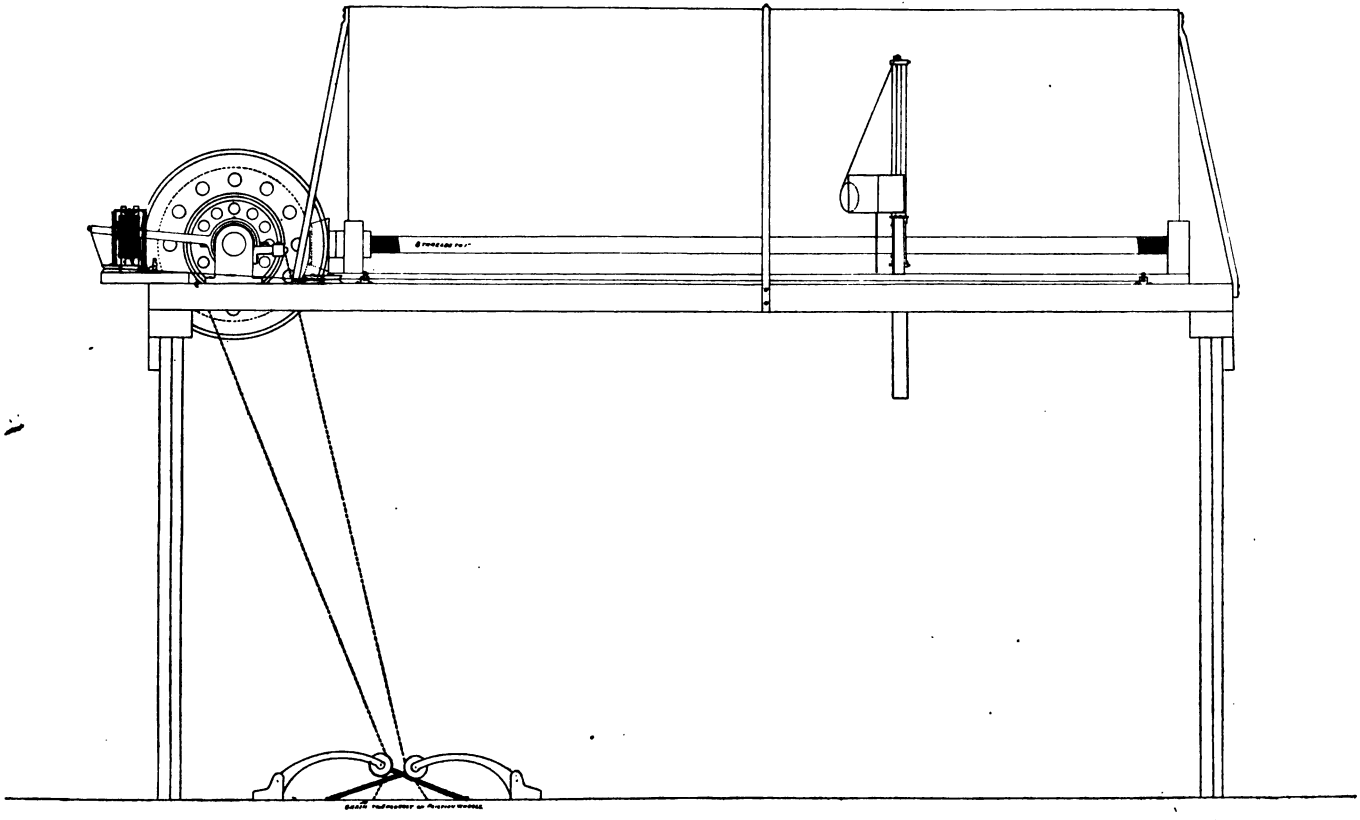
circuit was closed by means of various styles of contact points, and the testing operator was thus warned, by the bell on his table, that there was some premature or improper interference.

METHOD OF CALIBRATING.

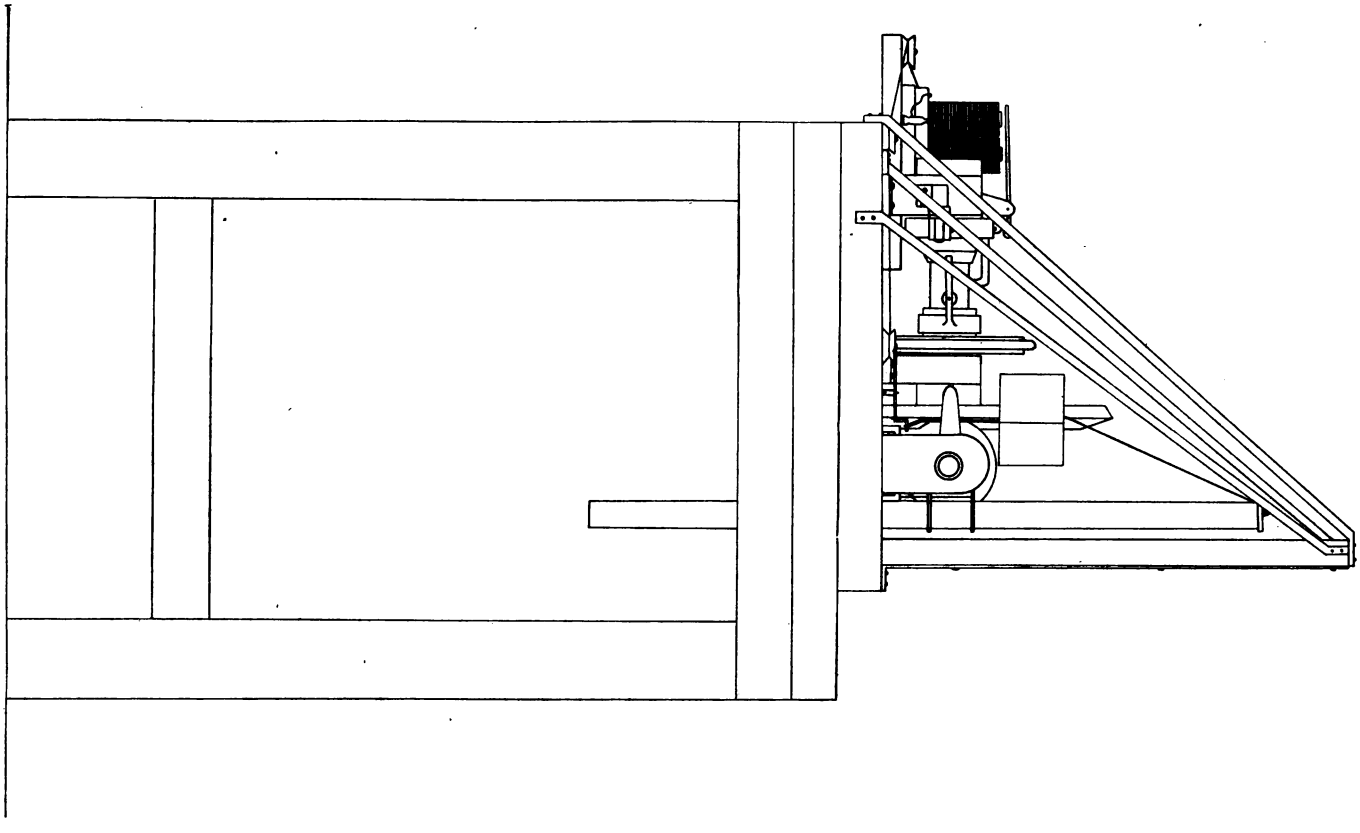
The instrument was calibrated on a track about 275 feet long, in the One Hundred and Forty-sixth street carhouse of the railway company, great care being taken with the measurements, timing, etc. To get the track travel of the car for one inch travel of the testing carriage, the car was run about 200 feet, the points of departure and stopping carefully marked and the distance between them measured, as was also the travel of the carriage. About eighteen readings were taken under various conditions, such as running the car slowly and at high speed; also with dry and wet rail. It was found that one inch travel of the carriage was equivalent to 47½ inches travel of the car; and, as the maximum travel of the carriage was 51½ inches, the maximum length of the stop that could be recorded was $51\frac{1}{2} \times 47\frac{1}{2}$, divided by 12, equal to 203½ feet.

To get the time constant, the movement was started while the car was in motion, and the time the pencil took to drop a given distance was noted on a stop-watch, reading to fifths of seconds. If the movement ran too slow, the staff was weighted with lead; if it ran too fast, lead was taken off until the necessary speed of drop was acquired. It was thought preferable to weight the staff instead of using a fly, so that a draught of air would have no effect on the results.

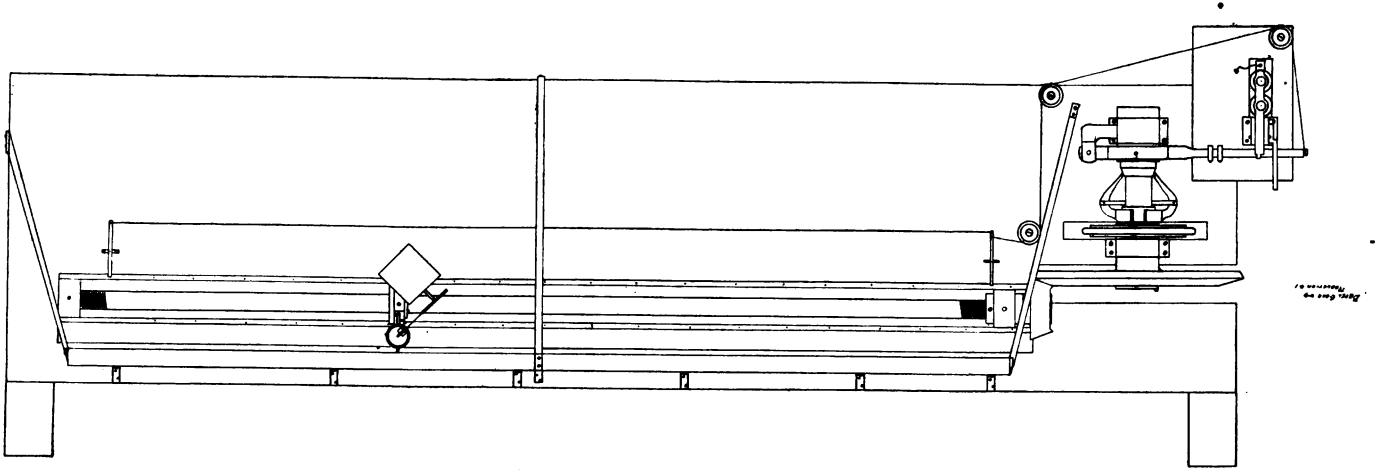
The movement was finally arranged to drop the weight 9 inches in 15 seconds, or 3-5 of an inch in one second, and, as the maximum drop of the weight and pencil was 10 inches, the maximum time range was 10 × 5-3, equal 16 2-3 seconds. The starting of the movement was very quick, as trials were made by timing the first and last half of the drop separately, but no appreciable difference could be detected.



Drawing No. 1 — Front view of recording apparatus.



Drawing No. 2 — End view of recording apparatus.



Drawing No. 3 — Top view of recording apparatus.

METHOD OF CONDUCTING TEST.

On each car 14 official speed records were taken; 3 at 8 miles per hour, 3 at 12 miles, 3 at 15 miles, 3 at 16 miles, and 2 at 16 miles, with sand.

In setting the instrument, the pencil was drawn up near the top of the paper and the clutch on the movement thrown in and the carriage brought to the extreme end of the instrument towards the front of the car. The split nut was then locked, the lever put in place to start the movement and the contact point on the speed indicator was set opposite the figure of speed required at which the car was to be stopped. When everything was in order a signal was given to the motorman to start the car. From this time the operator had nothing to do but watch the apparatus, to see that there was no failure of the parts to work properly.

When the predetermined speed was attained, the indicator hand made a contact with the metal stop on the dial of the speed indicator, thus closing the local circuit and setting in motion the recording instrument. This was kept in motion until the car came to a stop and the curve was automatically traced by the pencil on the paper. In addition to this record, the skidding of wheels was noted, a record being made of the number of wheels skidded and the number of feet that they slipped along the rails.

As soon as the record was taken the cone clutch was thrown out, the split nut unlocked, the carriage brought back to its first position, the pencil and everything readjusted, as stated. To avoid any dissatisfaction on the part of a contestant, he was given the option of personally applying the brake or leaving it in charge of the motorman.

The accompanying drawings, Nos. 1, 2, 3, show different views of the apparatus.

Arrangements were made with H. H. Vreeland, president of the Metropolitan Street Railway Company, under which each contestant was allowed to attach his brake equipments to one of the cars of that company. The tests were commenced on August 31 and completed December 2, 1899. During this interval a number of perhaps unavoidable delays occurred. A day for a test would be set and the Board would be present, only to find that some car had not been equipped as promised; thus that day would be lost. Again, when all was ready for the test, rain would prevent it, as tests were held only when the rail was perfectly dry. On several occasions the tests were interrupted by derangement of the braking apparatus, and a delay of two weeks was once caused by the speed indicator becoming disabled. The most serious delays, however, were caused by the failure of the contestants to equip cars within the time promised. This became so annoying that on October 2d the following letter was sent to parties who had received a permit, but who, up to that date, had failed to equip a car:

GENTLEMEN.— On July 13, 1899, the Board of Railroad Commissioners of the State of New York sent you permits to equip car and compete in tests of brakes to be held under its supervision.

The time within which the Board intended that the tests should be completed has long since expired. Therefore, I now notify you that unless you begin the work of equipping a car with your brake within the next ten days, I shall feel obliged to recommend to the Board that your permits be revoked.

Very respectfully,

C. R. BARNES,

Electrical Expert.

As before stated, the tests were held on the Lenox avenue line, between One Hundred and Thirty-fifth and One Hundred and Forty-sixth streets. Between these points the track is of 90-pound girder rail, 2-inch head, double track underground electric construction. From the accompanying profile of the track it will be seen that the distance, between the streets named, is 2,750 feet, and that there is a descending grade northward from One Hundred and Thirty-fifth street of 8.8 feet, nearly uniform between the points.

It was the intention to make the tests at initial speeds of 20, 16, 12 and 8 miles per hour, but it was found that the higher speeds could not be attained with the motor equipment used; so the tests were made at 16, 15, 12 and 8 miles per hour. These tests were made without sand; and two additional stops, at 16 miles, were made with sand.

The regular schedule cars were operated on the line during the tests. At One Hundred and Sixteenth street is a crossover which was used in going from the south to the northbound track. After making the southbound test stops, this crossover enabled the car to return and make the test stops on the northbound track. A flagman was stationed at each intersecting street to prevent accidents. After testing a car it was run into the car barn at One Hundred and Forty-seventh street and over a pit, where the testing apparatus was transferred to another car. On each of these changes four men were employed from two to four hours. Five employees of the company were on each car during the test. The largest number of brakes tested in one day was four.

Sixteen different brakes were tested, which can be divided into five classes, to wit:

AIR BRAKES.

1..... G. P. Magann Air Brake Company.
1..... Christensen Engineering Company.
1..... Standard Air Brake Company.
1..... John E. Reyburn.

ELECTRIC BRAKES.

1..... General Electric Company.
1..... Columbia Electric Light and Brake Company.
1..... Price, Darling & Co.
1..... Electric Selector and Signal Company.

HAND POWER BRAKES.

1..... Sterling Supply and Manufacturing Company.
1..... M. H. Vogel.
1..... Sauvage Street Car Brake Company.

FRICTION BRAKES.

1..... Peckham Motor, Truck and Wheel Company.
1..... J. G. Brill & Co.

TRACK AND WHEEL BRAKES.

1..... Devlin Street Car Brake Company.
1..... Philip Bach and Bernard Schlegel.

In addition to the foregoing list, there was tested a system of brake levers entered by the Safety Appliance Company.

Each contestant furnished to the Board a detailed description of his brake, together with a presentation of its claims of merit. From these descriptions the following abstracts are made, explaining the mechanical principle of each brake:

AIR BRAKES.

The reliability of the air brake has been thoroughly established by its use on steam roads. A large number of them are now used on electric cars, and, with proper inspection and care, the air brake, as applied to electric cars, is a reliable, powerful, quick and easily controlled means of applying the braking power to a car wheel. Four systems of air brakes were submitted and tested. All were similar, so far as relates to the use of air under compression in a cylinder, to operate a piston from which, through levers, the power was transmitted to the brake shoes. They differed in the method of compressing the air and applying it to the piston.

The G. P. Magann Air Brake Company presented what is known as a storage air system, in which there is an air compressor and reservoir located at the power-house or some central point on the street-car system. This reservoir is charged with air usually compressed to 300 pounds pressure. The car is equipped with two storage reservoirs, which are charged in a few seconds from the stationary reservoir at 300 pounds pressure. By means of a reducing valve this

pressure is reduced to 50 pounds, at which pressure the air enters an auxiliary reservoir, from which it is controlled, to the brake cylinder by means of the engineer's valve, in the usual manner. There are some special features in the construction and operation of this valve. The storage equipment of cars is calculated for 300 stops, which is sufficient for ordinary car operation; when necessary this capacity can be increased.

The Christensen Engineering Company presented what is known as the straight-air system, which consists of a reservoir, an electric motor compressor, an automatic regulator which governs the operation of the motor compressor; an engineer's valve and the usual brake cylinder. In this system, as its name implies, the compressed air passes direct from the reservoir to the brake cylinder, there being no auxiliary reservoirs or reducing valves between the pressure reservoir and the brake cylinder. All of this apparatus, with the exception of the controller, is placed under the car. There are a number of special features in the construction and operation of the system as presented by this company.

The Standard Air Brake Company presented an automatic air-brake system, consisting of an electric motor-driven compressor, a storage-pressure reservoir, a motor controller, brake cylinder and engineer's valve. This system is similar to the one described above, except that there are a number of special features in construction and operation in which the two systems differ; the general principle of compressing and applying the air is, however, the same.

John E. Reyburn presented an air-brake system similar to the two last described, except that the compressor was operated mechanically instead of by an electric motor. This compressor was worked by the motion of the car axle, which was transferred to the compressor by means of friction discs or wheels, one of which revolved with the axle, the other being fast on the compressor shaft. These were placed in such position that they made a firm frictional contact. These friction discs are thrown into contact

and released by compressed air from the reservoir. After the air has been compressed in the cylinder, the operation is the same as usual in air-brake systems.

ELECTRIC BRAKES.

There were four electric brakes tested. The only electric brake which is at present used to any extent by electric railroads is the one presented by the General Electric Company. The development of the electric brake up to the time of this test was mostly confined to that company.

The Electric Selector and Signal Company presented an electric or magnetic brake, operated by the trolley current. This brake consisted of a series of magnets, the armatures of which are at varying distances from the magnets, all mounted loosely on the same rod and in such a manner that the attraction of the armature nearest to the core carries with it the armature next in distance from its core to a point of greater magnetization, and so on, each armature acts upon the next, thus creating a long and powerful pull. These armatures are arranged on a rod which forms a part of the ordinary brake rod. This brake can be applied to the ordinary spindle hand brake. The movement of the brake handle sets the electric brake in operation, and this movement can be continued, setting up the shoes by hand without interference from the electric portion of the brake, so that in case of failure of the current the brake can be set by hand. The hand brake is under test at times when the electric brake is used, thus insuring it being in working condition, in case of failure of the trolley current. A maximum of five amperes of current is used in the operation of this brake.

The General Electric Company presented an electric brake which is in use on several electric roads in this State. The construction and operation of this brake is as follows: Each motor is fitted on the commutator end with a cast steel yoke provided with two horns, which project on each side of the axle and support the brake shoe. This shoe is 26 inches in diameter, and consists of two cast iron halves, a crescent-shaped slot being cast in each half,

which holds the energizing coil. A cast-iron wearing plate is bolted to the face of the shoe and is provided with slots directly over the slots in the main shoe casting. These slots are filled with an antimony-lead alloy, which thoroughly protects the coils from injury and at the same time increases the smoothness of the braking. The disc, with which the brake shoe is drawn into contact, when energized, is cast as a part of the car wheel, and is merely a finished surface on the inside of the wheel. The wear on the brake shoes is taken up by means of adjusting screws on the brake support. The braking is accomplished in the usual manner, by converting the motors into generators and passing the current thus generated through the brake shoes and a regulating resistance. With this method of braking it is immaterial whether the plow is in contact with the conduit rails, or the trolley wheel with the wire, or not, as the braking power is obtained from the momentum of the car. The braking effort is due partially to the back torque of the motors acting as generators and partially to the friction between the shoes and the wheel discs, and is about equally divided between the two. The controller has a single operating cylinder, which is rotated in one direction for power and in the opposite direction for brake. The brake shoe on each axle is directly in series with the armature of the motor on the same axle. If either shoe tends to lock, due to the too rapid application of the brake, the axle will cease to turn, or, at least, slow down, with the result that the armature in series with the shoe ceases to generate as great a voltage as the armature of the other motor. The natural result is that the current will pass through the locked shoe in the reverse direction and demagnetize it, allowing it to release. The shoes are demagnetized in the usual manner, by shunting a portion of the current on the first power point through them in the reverse direction, thus allowing them to release and drop away from the disc. The location of the apparatus, of course, is arbitrary, the cables having taps located at the proper points for connection to it.

Two other electric brakes were tested, but as they did not meet the requirements of the test, no description of them is given.

HAND POWER BRAKES.

Three systems of hand power brakes were tested.

The Sterling Supply Company presented a hand power brake which is quite extensively used, the Metropolitan Street Railway Company of New York city using it exclusively. It consists of gear wheels applied to the ordinary spindle, which multiply the power applied to the brake handle. This brake is equipped with a double brake chain.

Martin H. Vogel presented a newly devised and effective hand power brake. It is constructed by applying eccentric gear wheels to the ordinary brake spindle, so that the first movement of the brake handle brings the eccentric gear wheels in such position that their speed is multiplied and their power reduced. As the revolution of the spindle continues, this condition changes with the movement of the brake handle to one of multiplied power and reduced speed. This results in quick action in taking up the slack of the brake chain, and increased power on the final movement, when power is required to set the shoe against the face of the wheel. This brake is devised and intended for the double chain connection, from the drum to the brake levers.

The Sauvage Street Car Brake Company presented a novel brake system, constructed on the principle of a wedge working against a wheel. The forward brake shoe is attached to a double wedge, which is formed of two wedges united at their thin edges. Back of this is a roller connected to a thrust bar, reaching from wheel to wheel, the shoe for the second wheel being attached to the further end of this thrust bar and acting directly upon the wheel. This is the simplest form of the brake, but in double trucks with wheels of different diameters carrying different weights, a device must be used whereby the pressure on the brake shoes is made proportional to the weight carried on the respective wheels. The further end of the thrust bar is connected by ball joint with a vertical lever, which carries the brake shoe for the little wheel, the

relative pressure on the two shoes being determined by the relative length of the lever arms. The application of the brake consists in raising or lowering the wedge between the roller and the revolving wheel. The effect of this is to move the shoe towards the wheel until it comes in contact with the revolving surface. As soon as this contact begins the friction between the shoe and wheel tends to tighten the brake. If the wheel is turning upward and the wedge is moved upward the friction on the wheel will tend to move it further upward and increase the pressure; if the wheel is turning downward and the wedge is moved downward, the friction on the wheel will tend to move it further downward and increase the pressure. The object of the double wedge is to have a brake which will act on wheels turning in either direction. The only difference in the connections used in this brake and those of the ordinary hand brake consists of the two arms, one placed on each side of the thrust bar. These arms have slots in them in which a pin, passing through the centre of the wedge, rests. As these arms are moved up and down by the motorneer they carry the wedge with them and suitable connections enable the motorneer to move the wedge up and down between the thrust bar and the wheel at his discretion.

FRICTION BRAKES.

There were two friction brakes tested. This class of brake is used on several of the roads in this State.

The Peckham Motor Truck and Wheel Company presented a friction brake known as "The Price Brake," which consists of a friction device placed on one of the axles of the car. This friction is in the form of two discs, one of which revolves with the axle, the other being attached to a loose collar or sleeve which is placed on the axle. To this sleeve a chain is attached and extends to the sway bar of the brake rigging. These discs are brought together by leverage operated by the motorman; this imparts the motion of the axle to the loose sleeve, winding up the chain and in this manner setting the shoes.

The J. G. Brill Company presented a friction brake in principle similar to the one described above, but differing from it in some of the details of construction and operation.

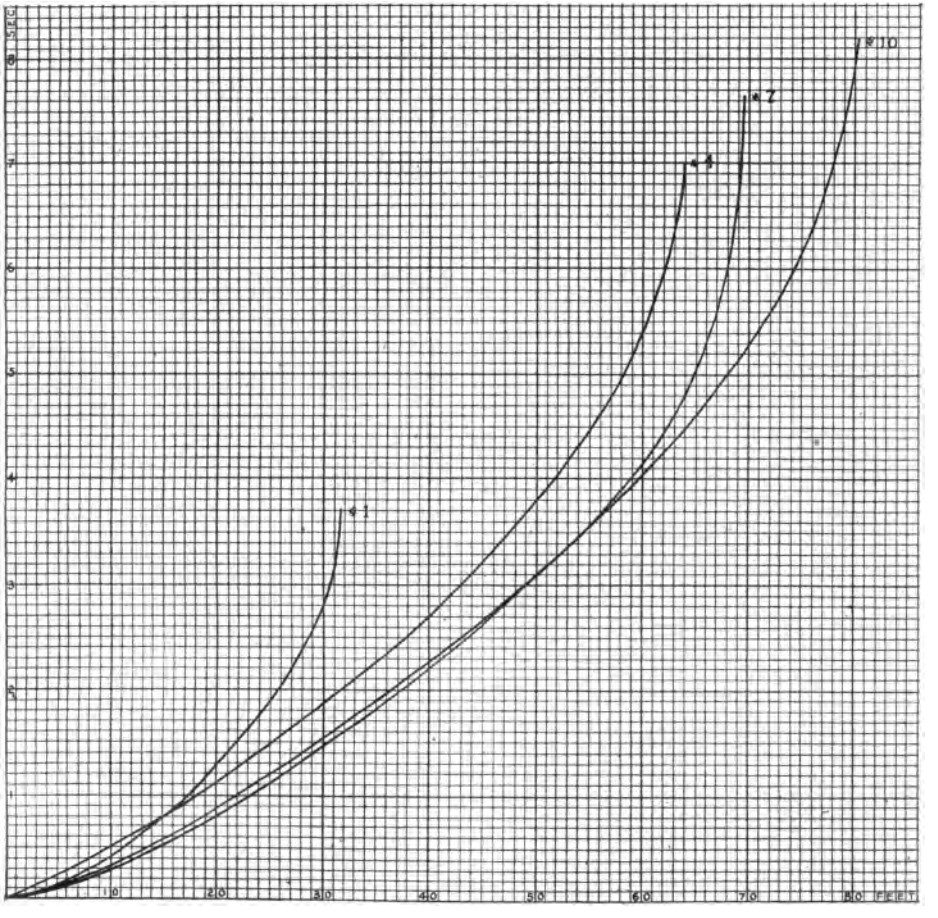
TRACK AND WHEEL BRAKES.

The Devlin Street Car Brake Company presented a track and wheel brake. In the construction of this brake there is a brake head with two shoes, one fitted for the wheel, the other on the bottom of the head to fit the rail. The head is suspended by springs in such a manner that when the shoe is applied to the wheel the movement of the wheel causes the brake in front of it to be forced down, bringing the track shoe into operation. This shoe also acts as a fender, preventing anything from going under the wheel. This brake is operated by friction power, the usual friction discs being used.

Another track and wheel brake was presented, which did not meet the requirement of the test, and therefore is not described.

RESULTS.

The results of the tests are given in the following diagrams of curves, which are reduced by measurements and photography, from the original recording instrument curves. On each diagram are explanatory notes:



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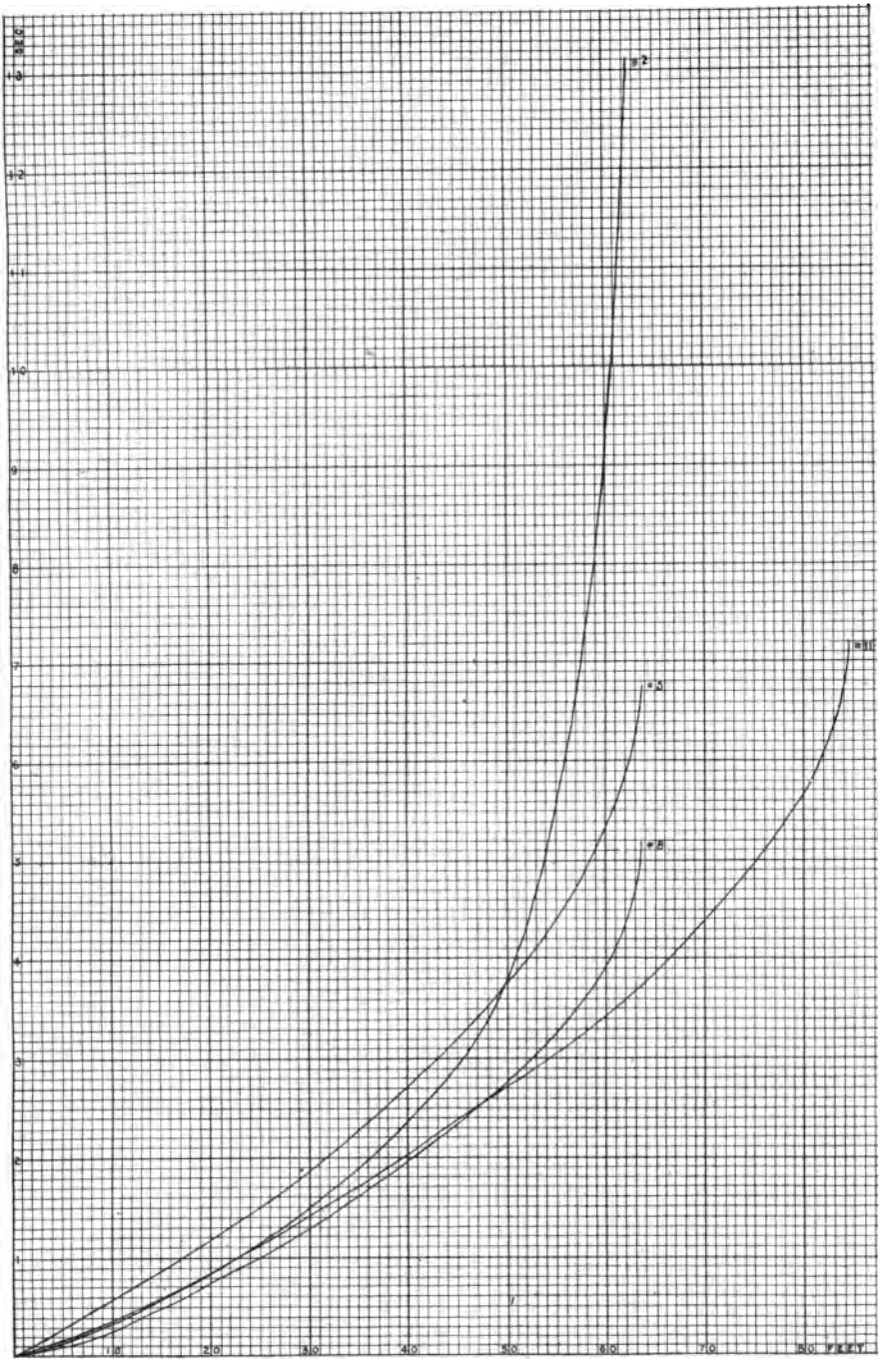

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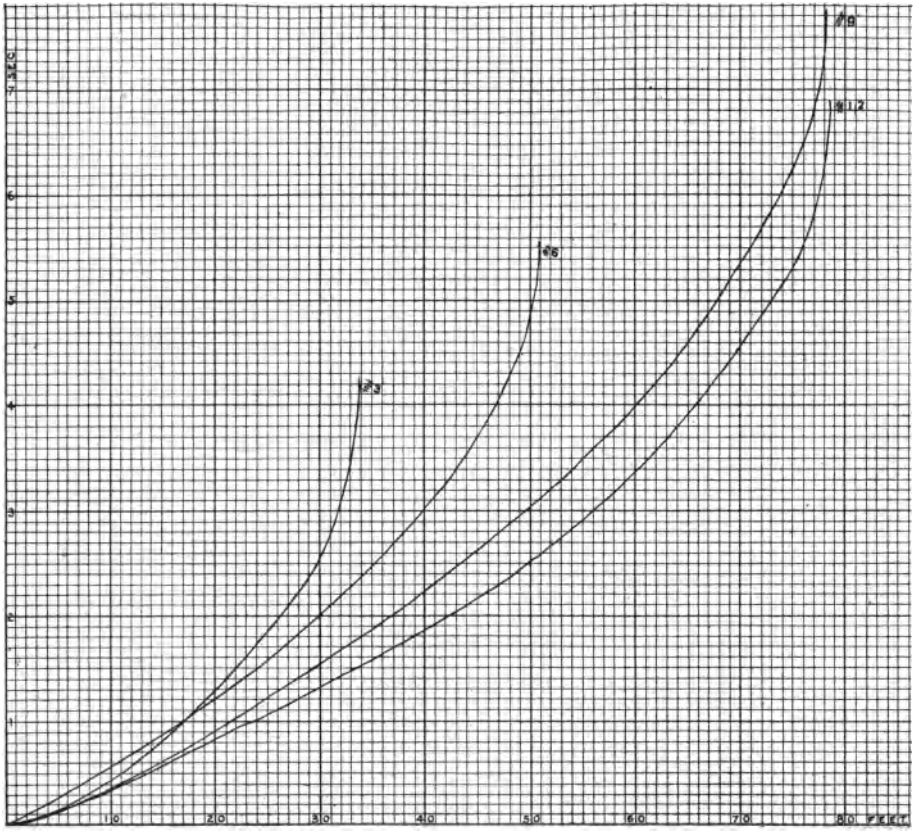

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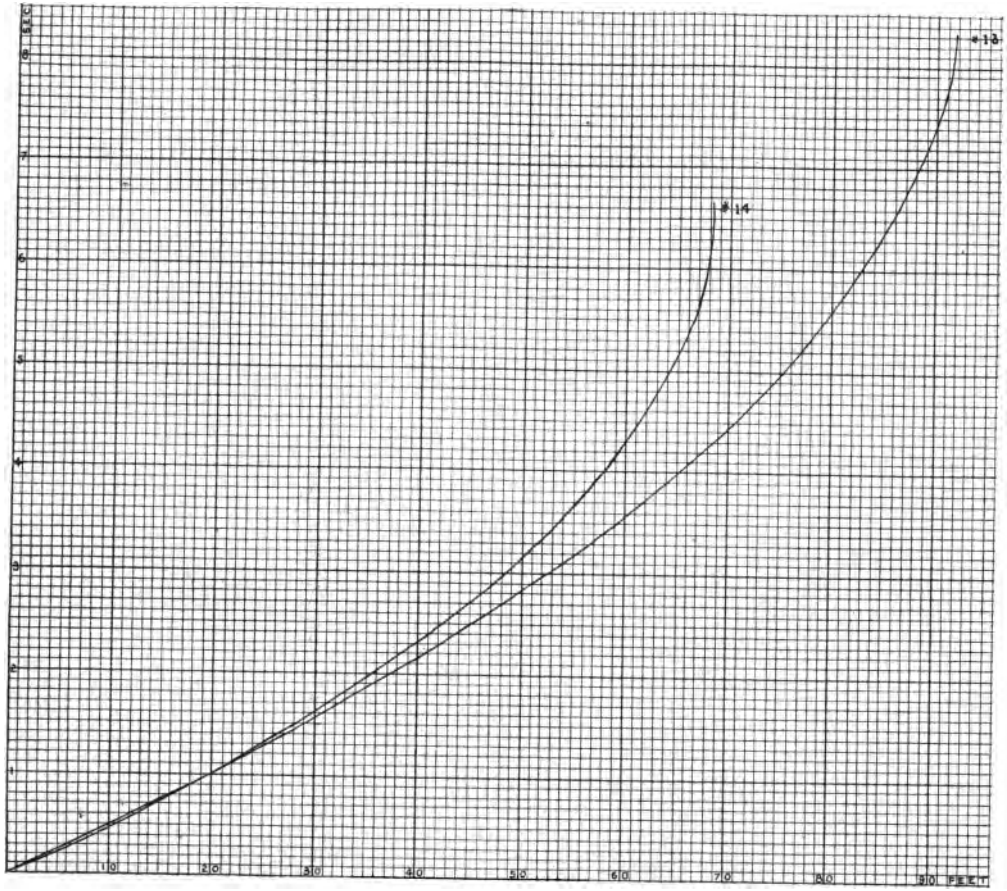

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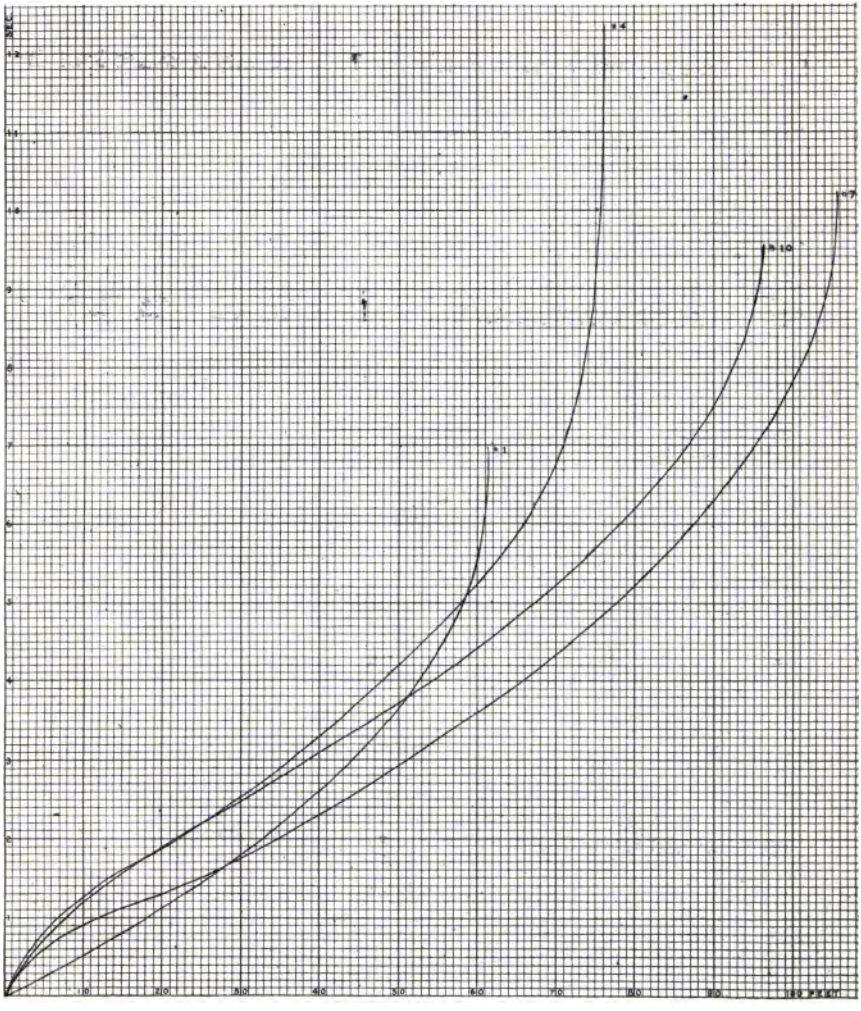

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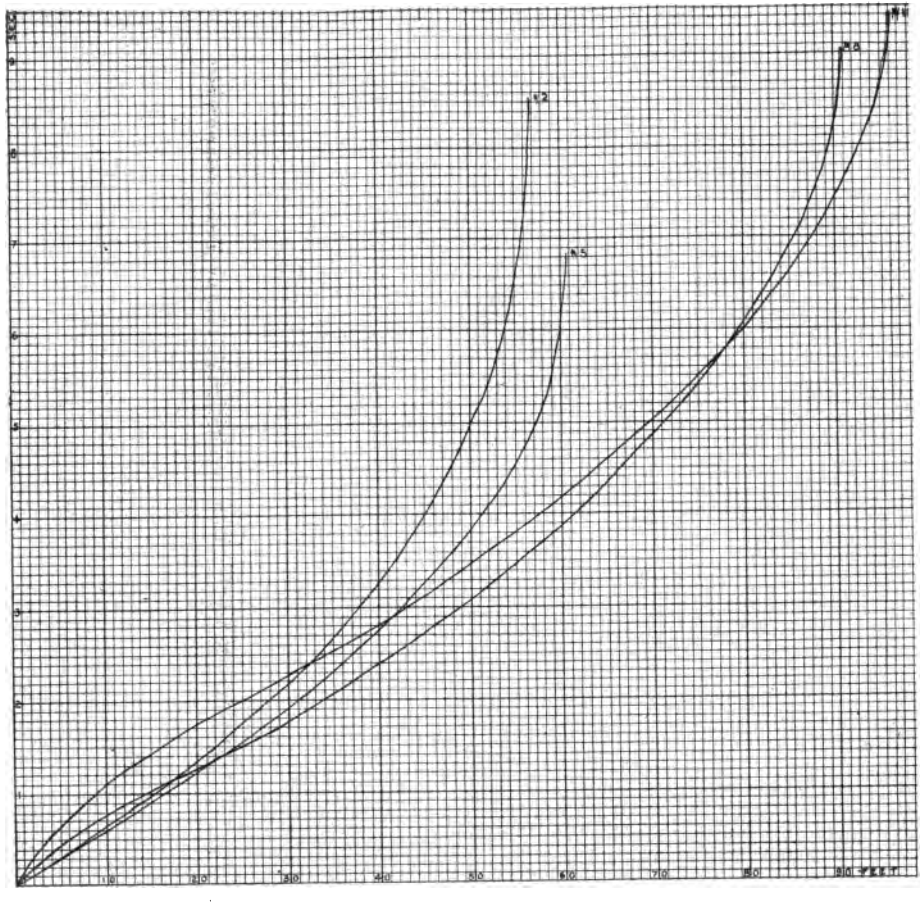

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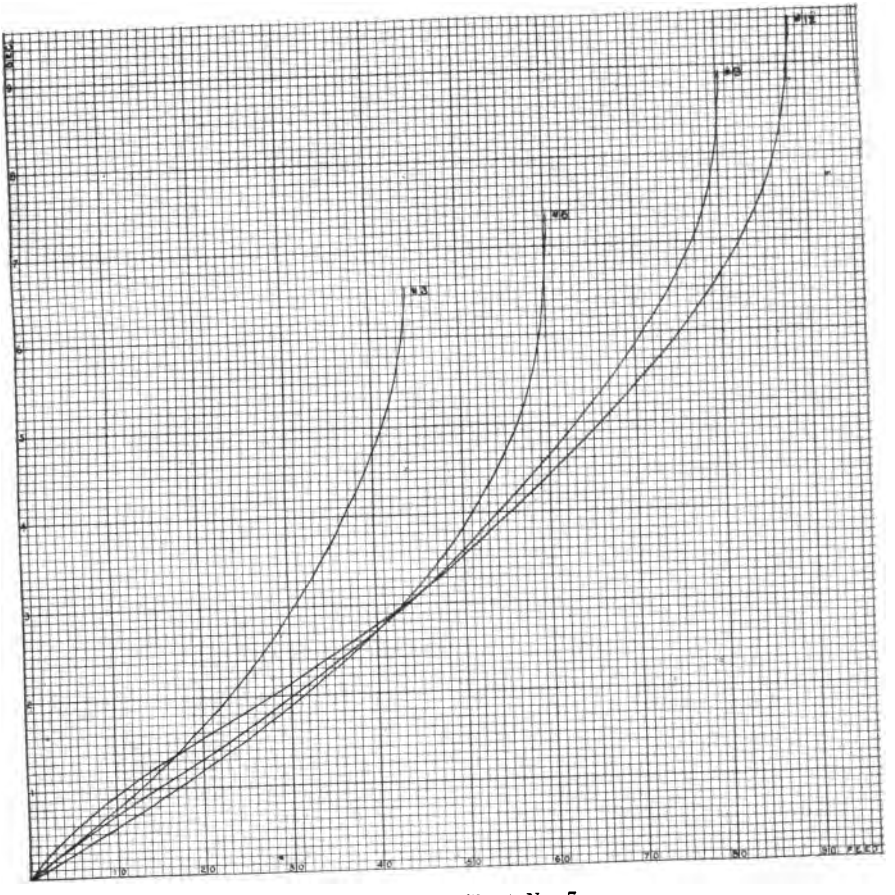

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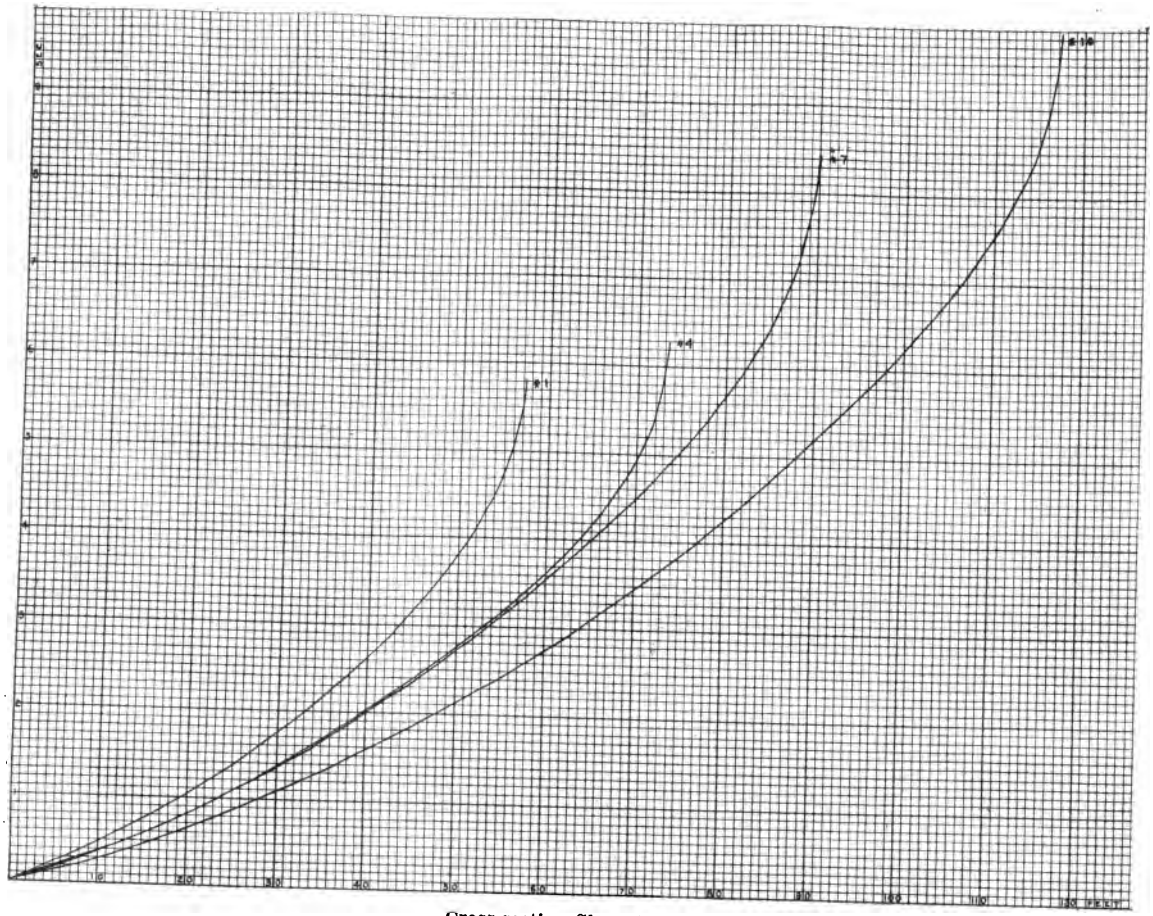

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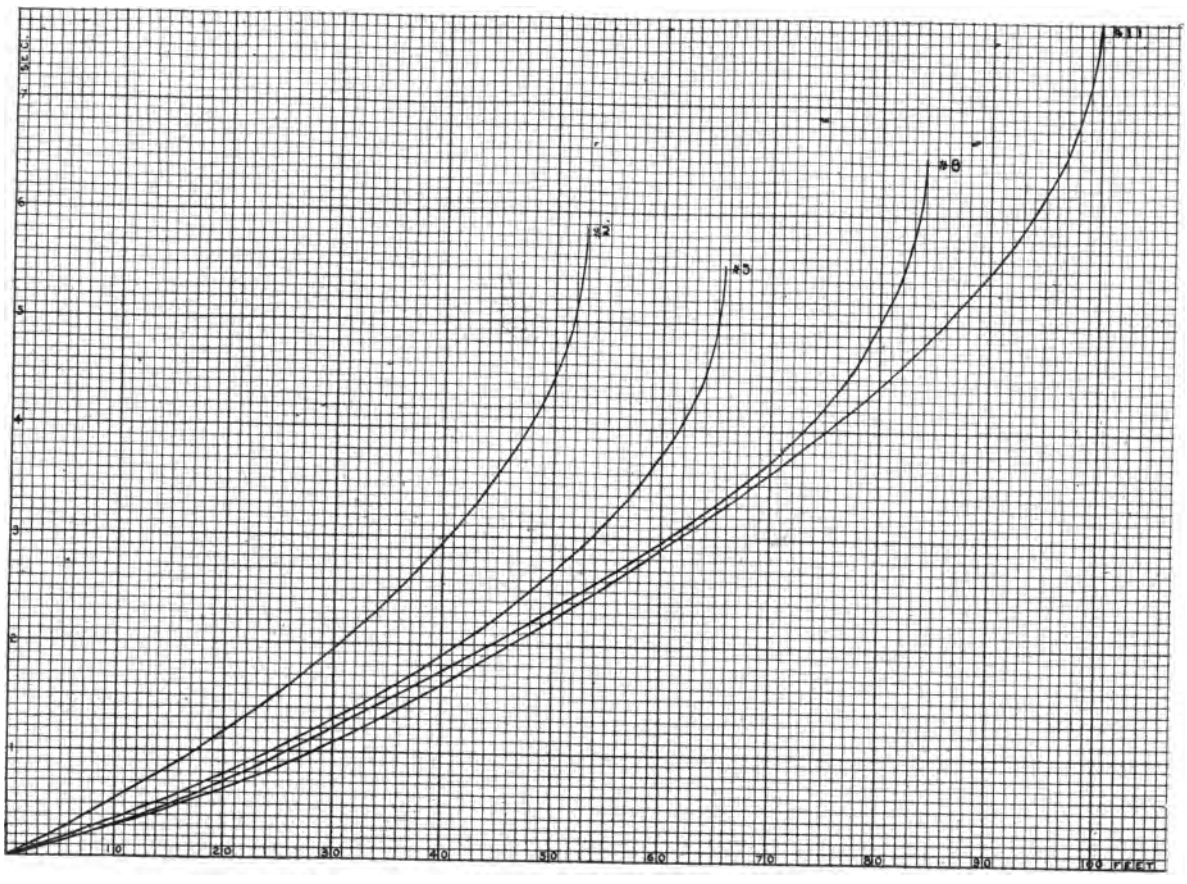

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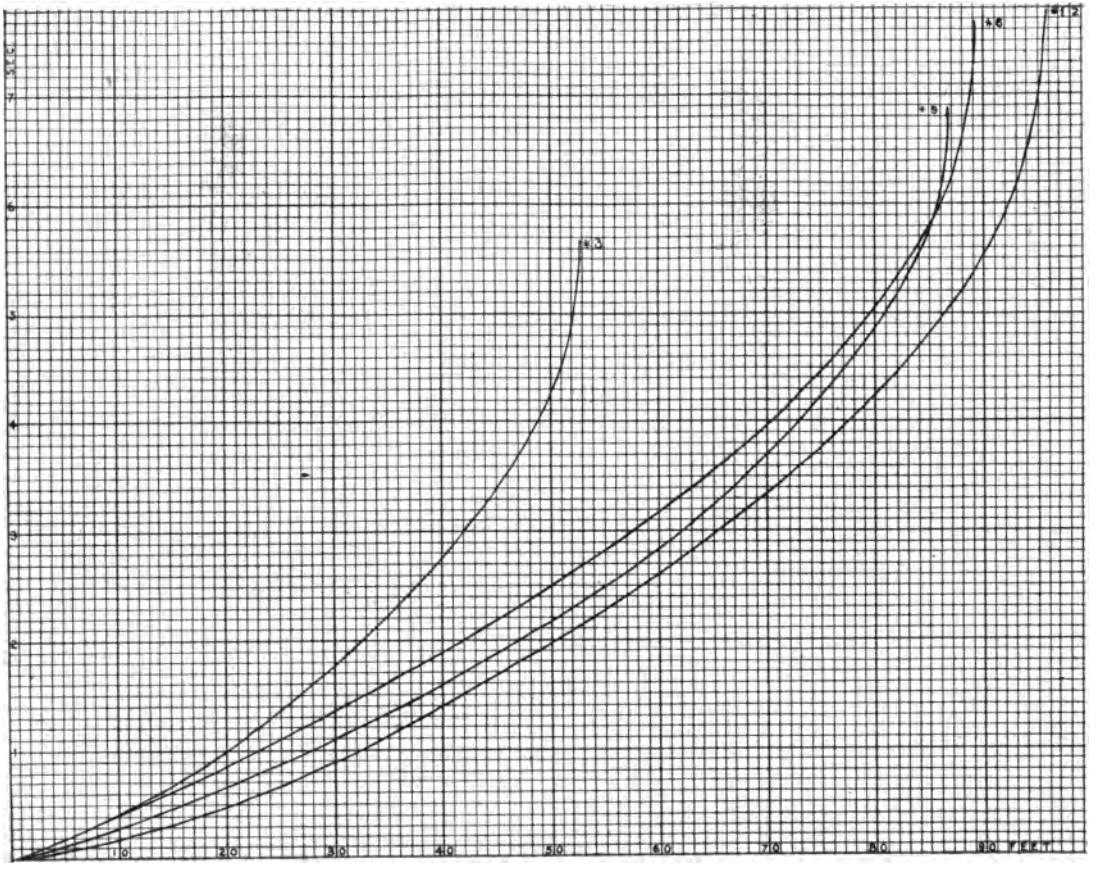

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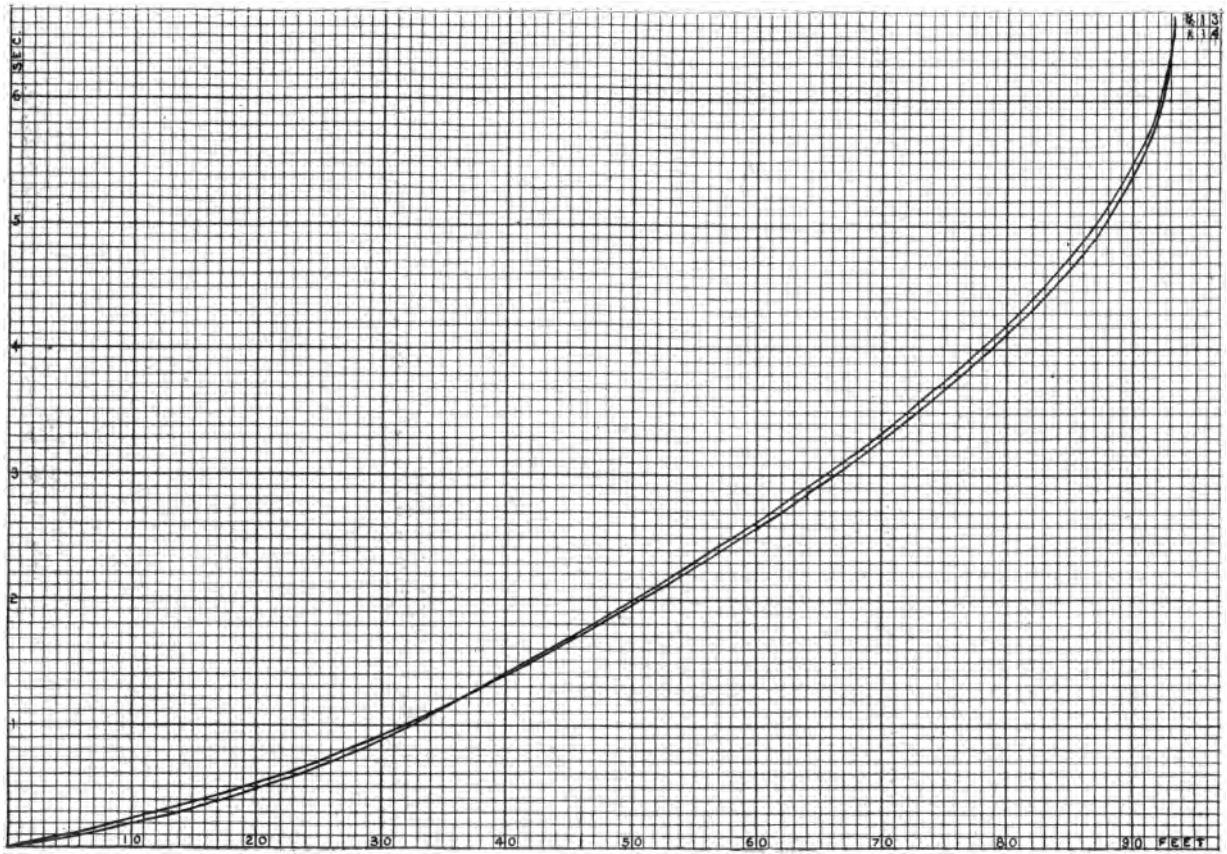

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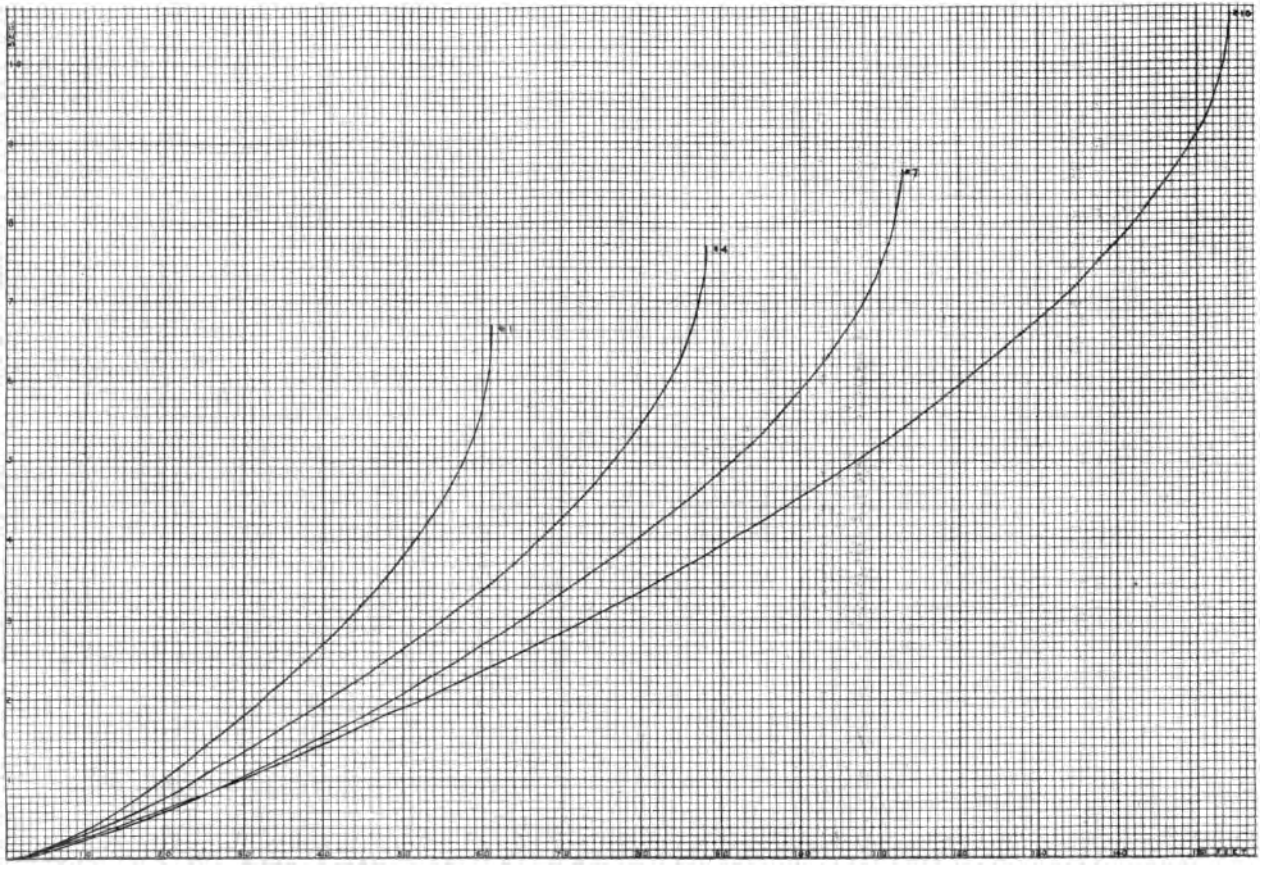

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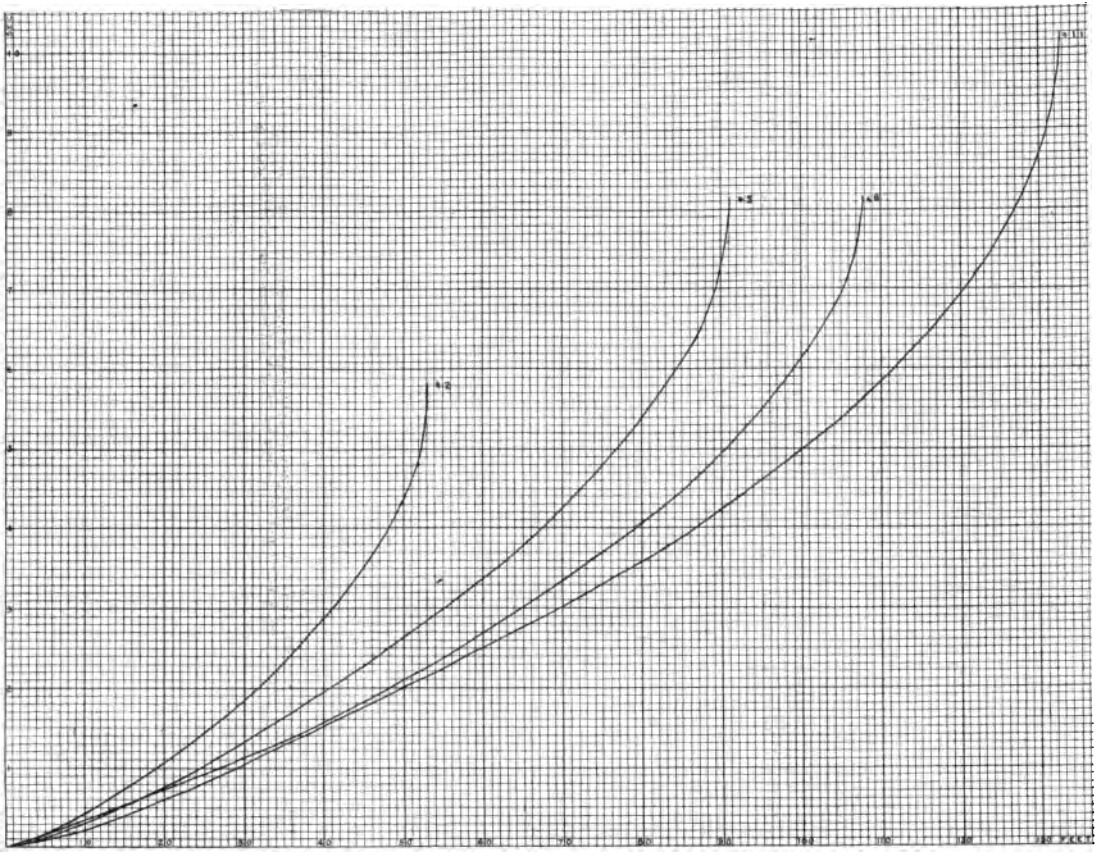

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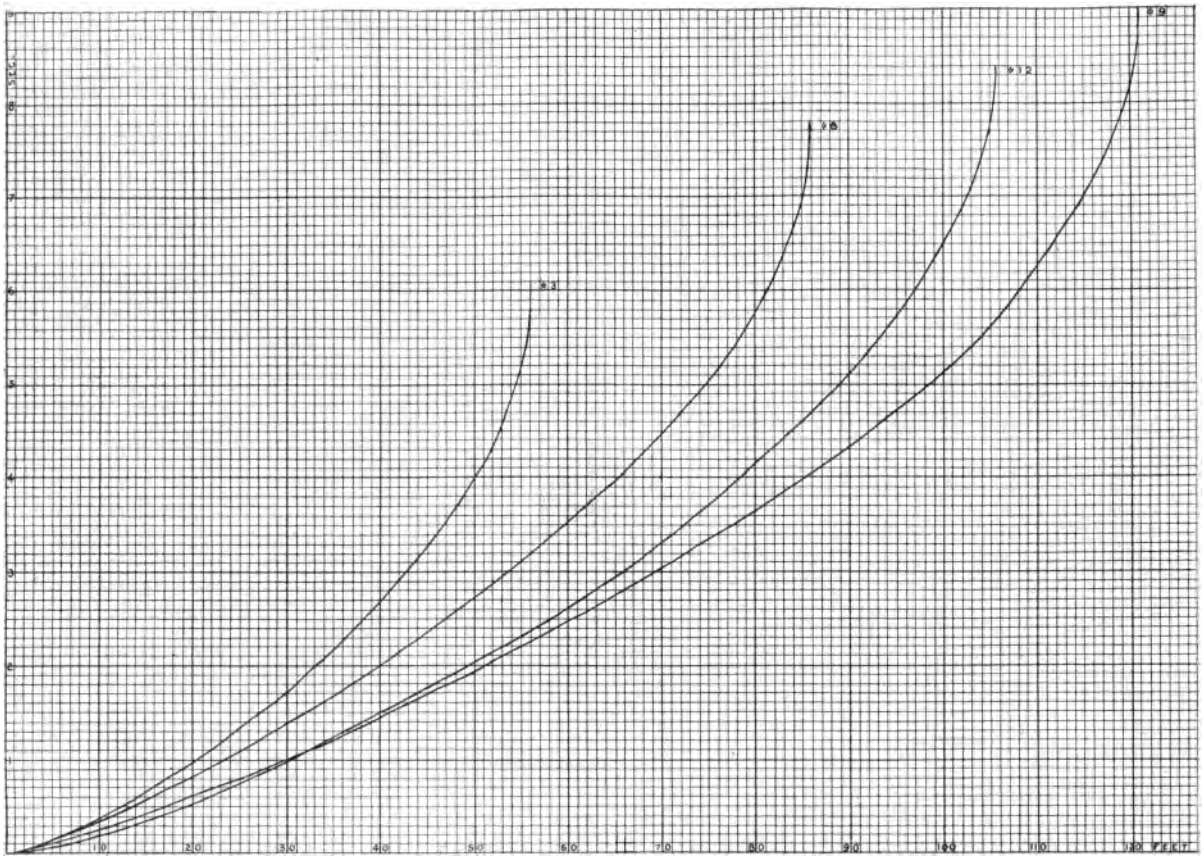

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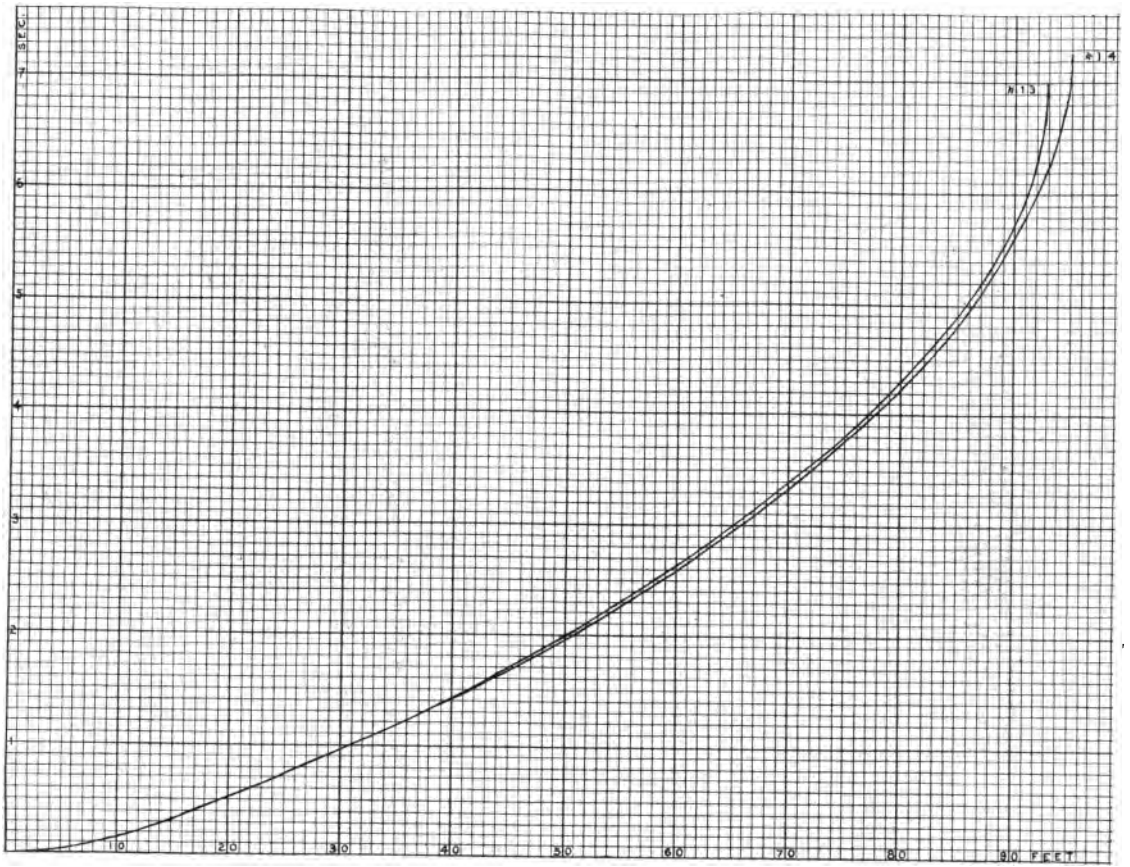

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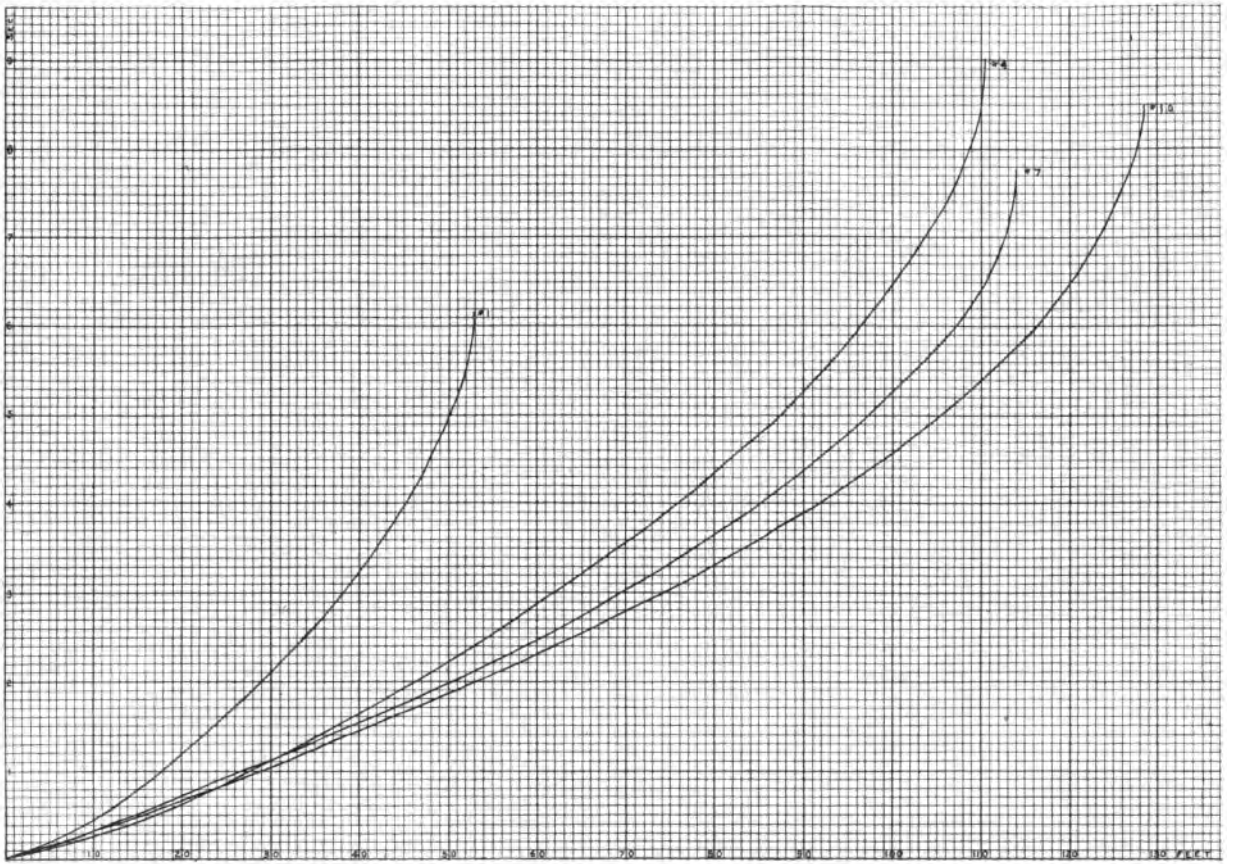

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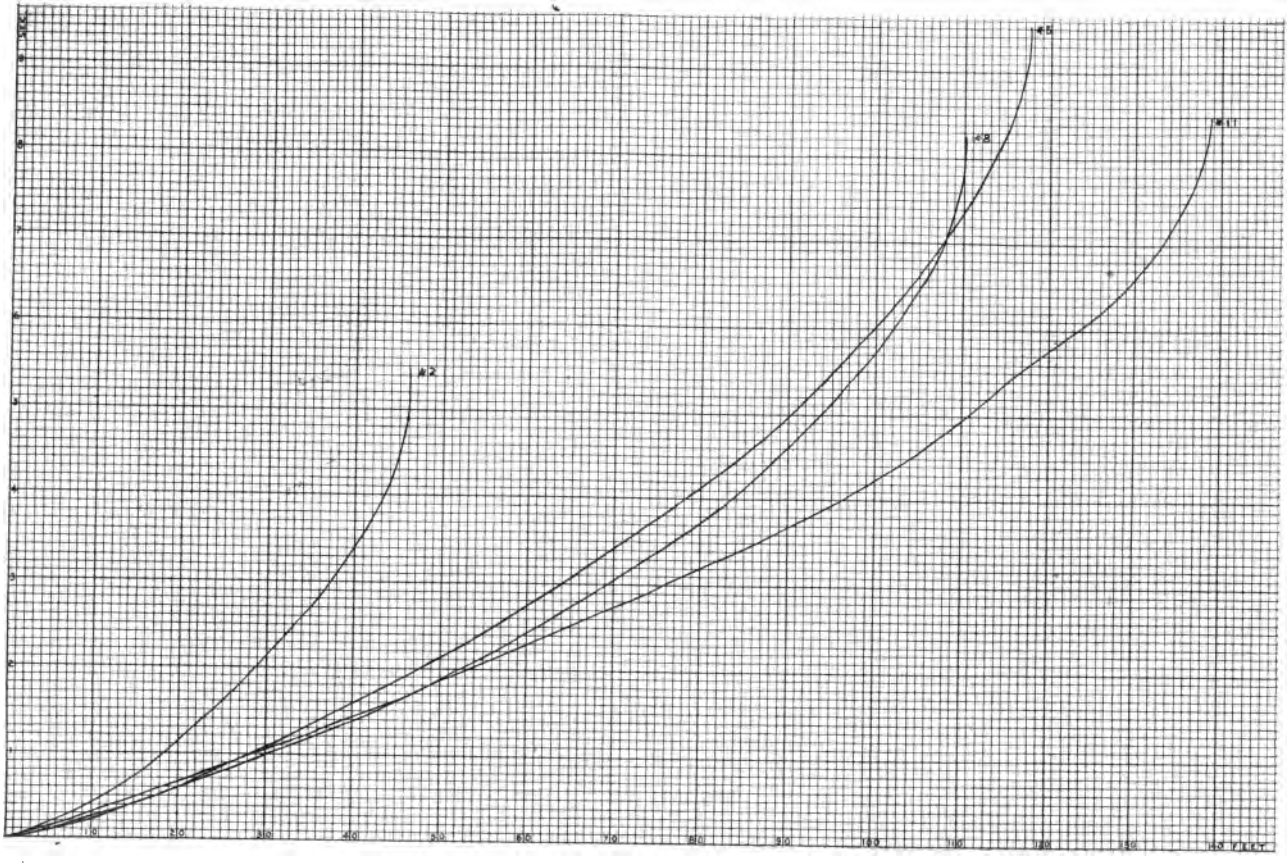

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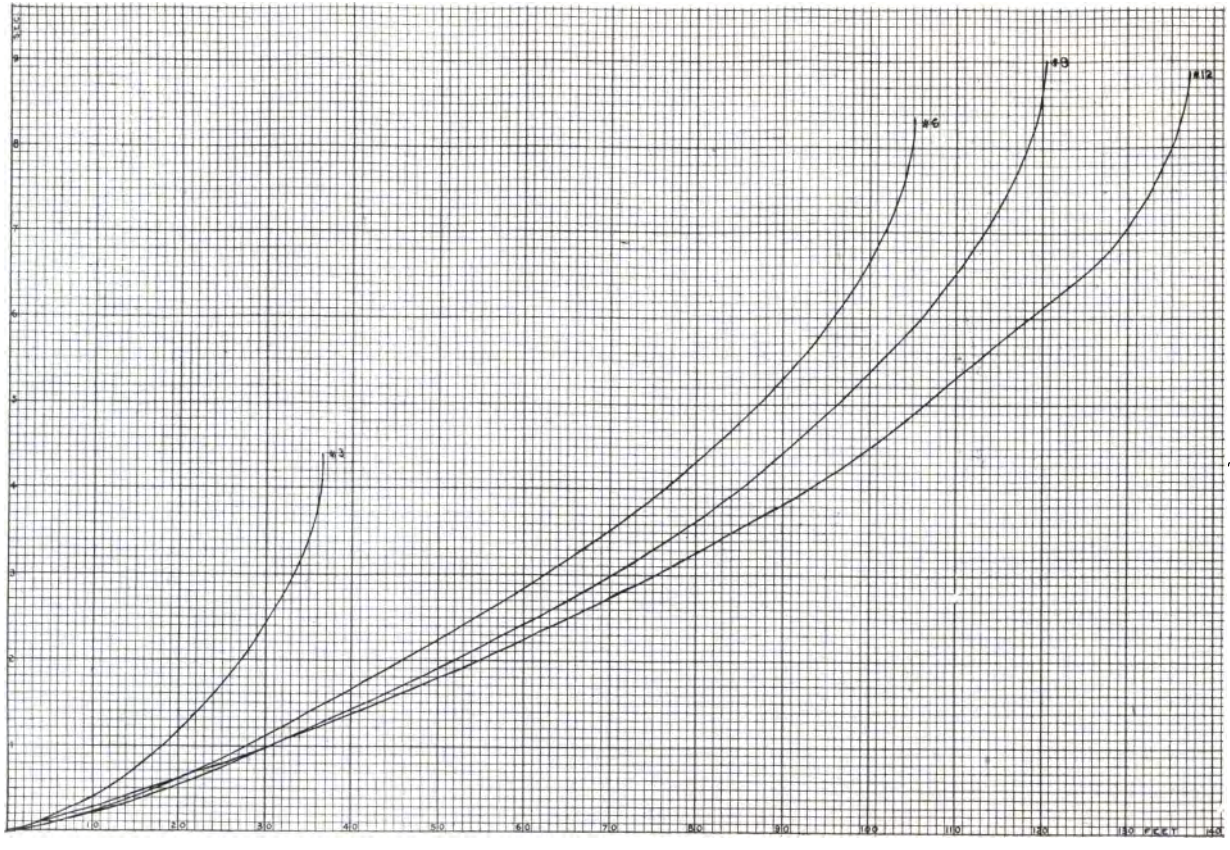

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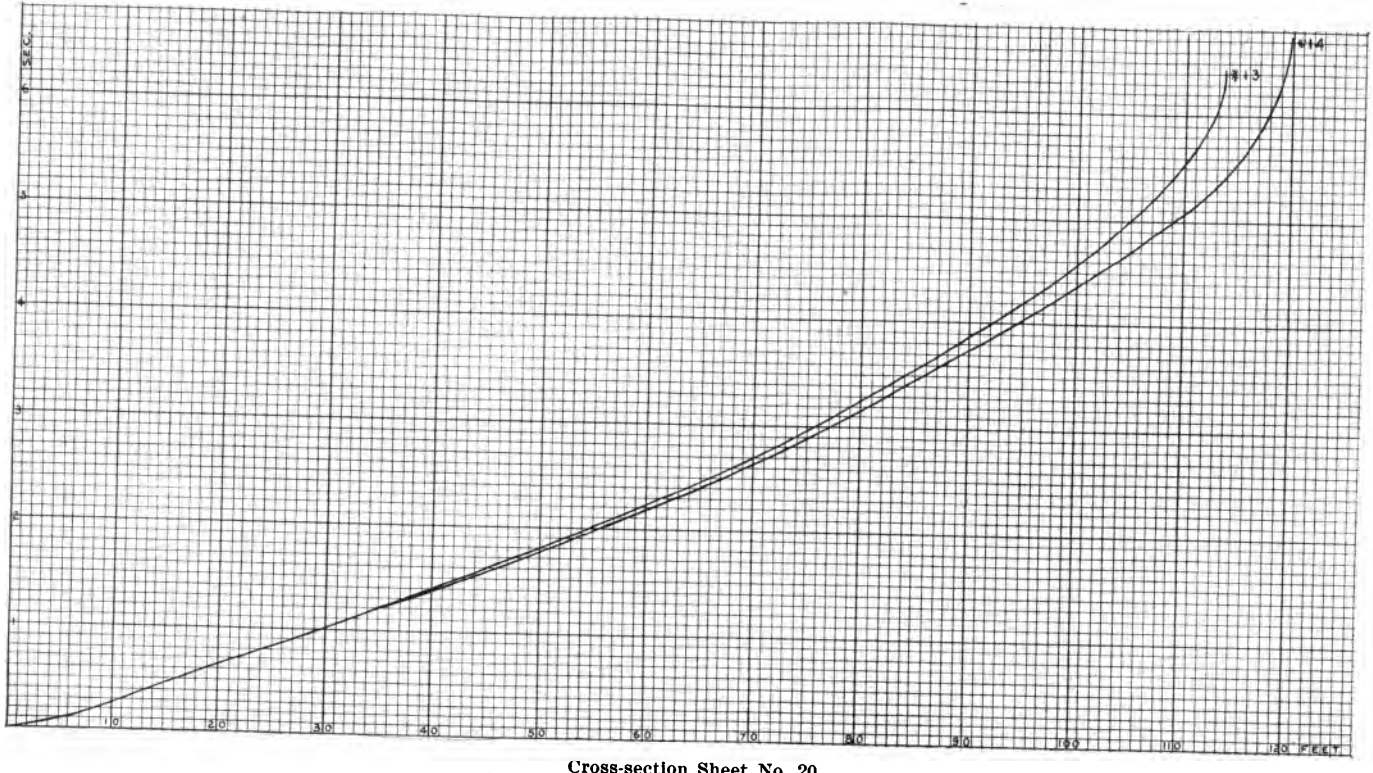

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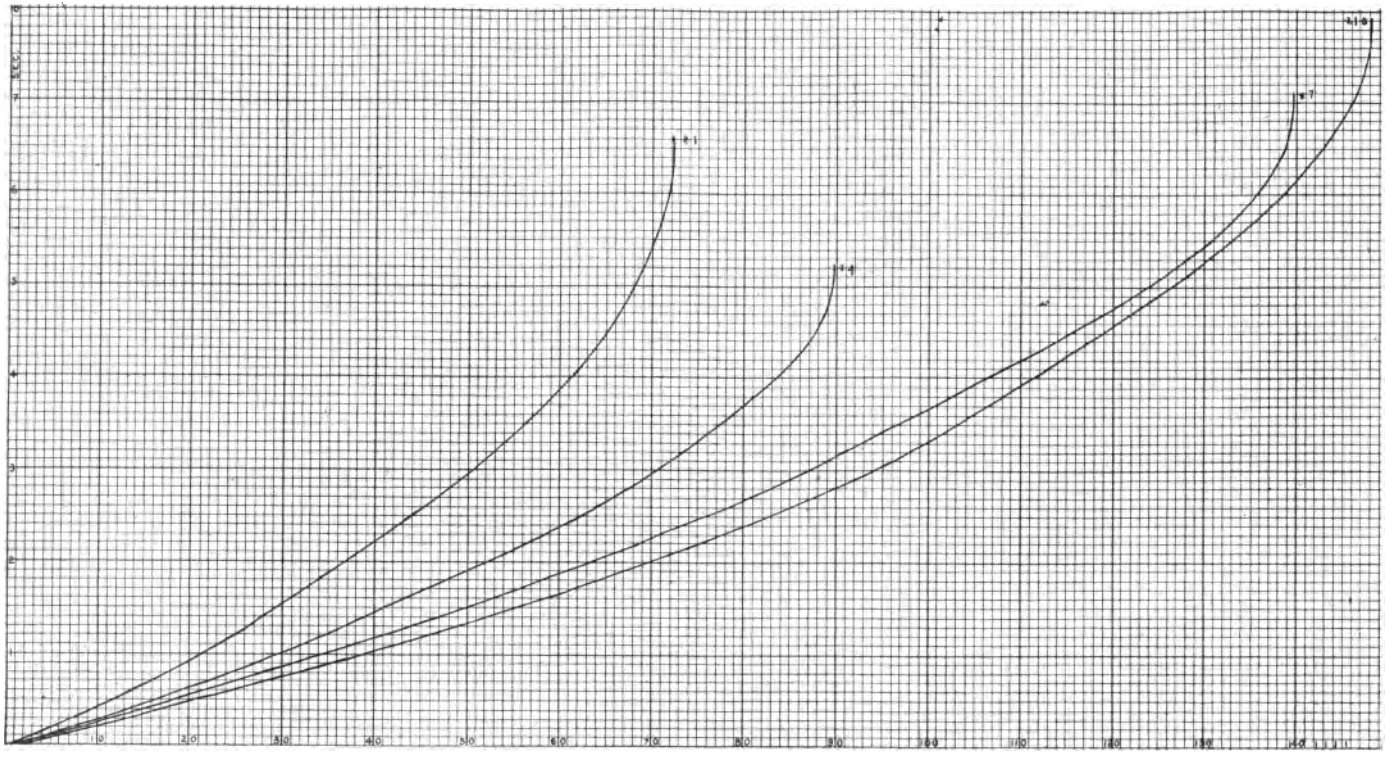

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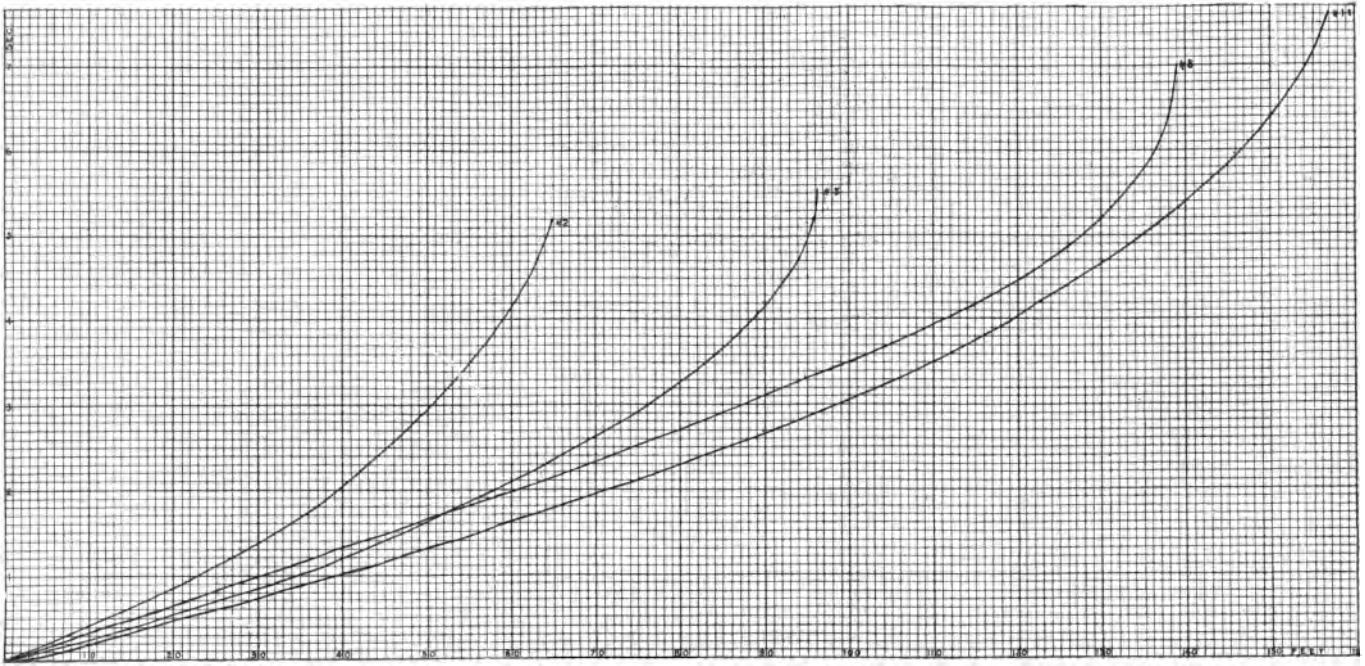

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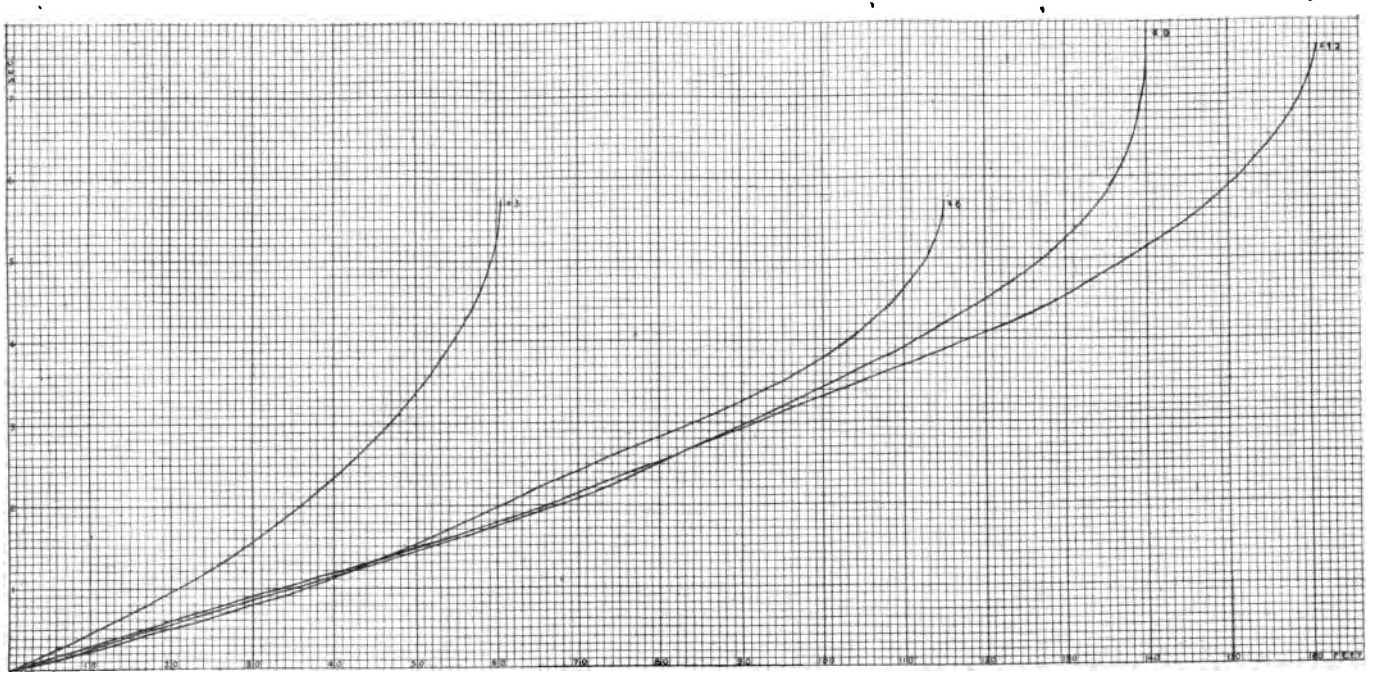

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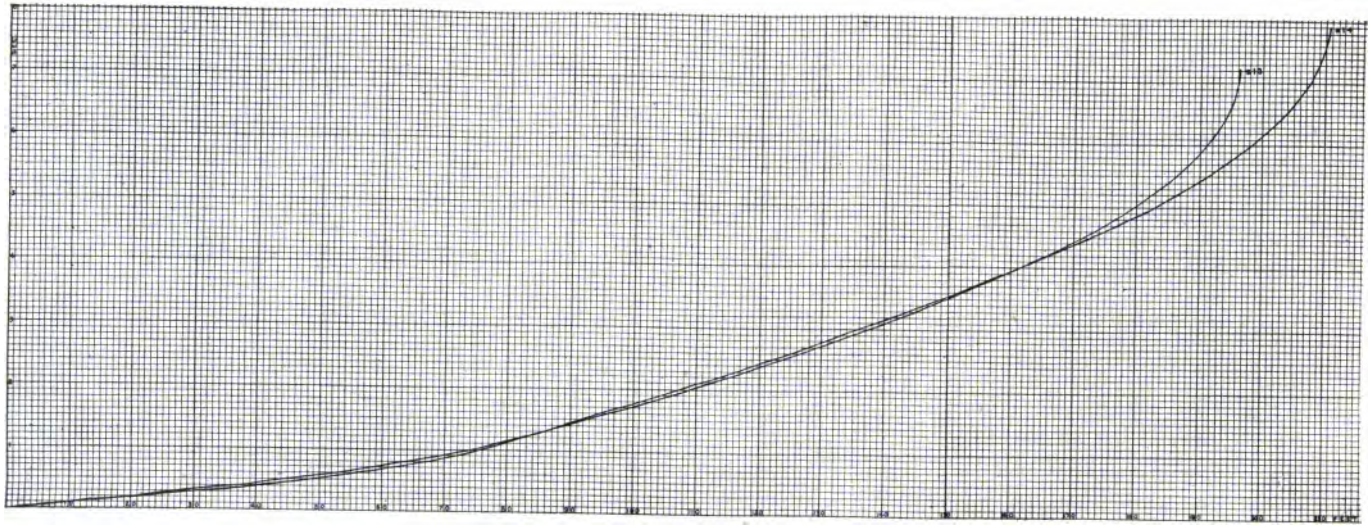

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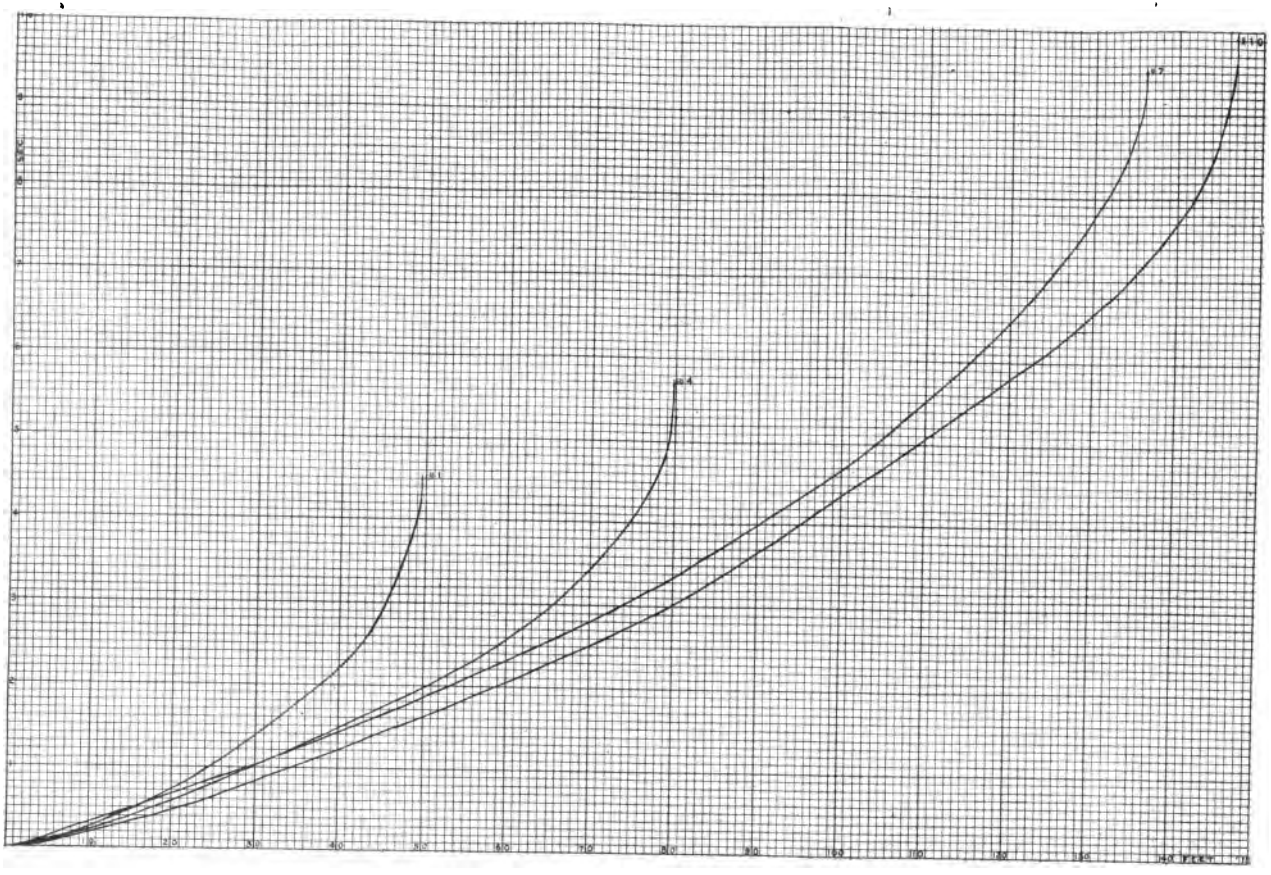

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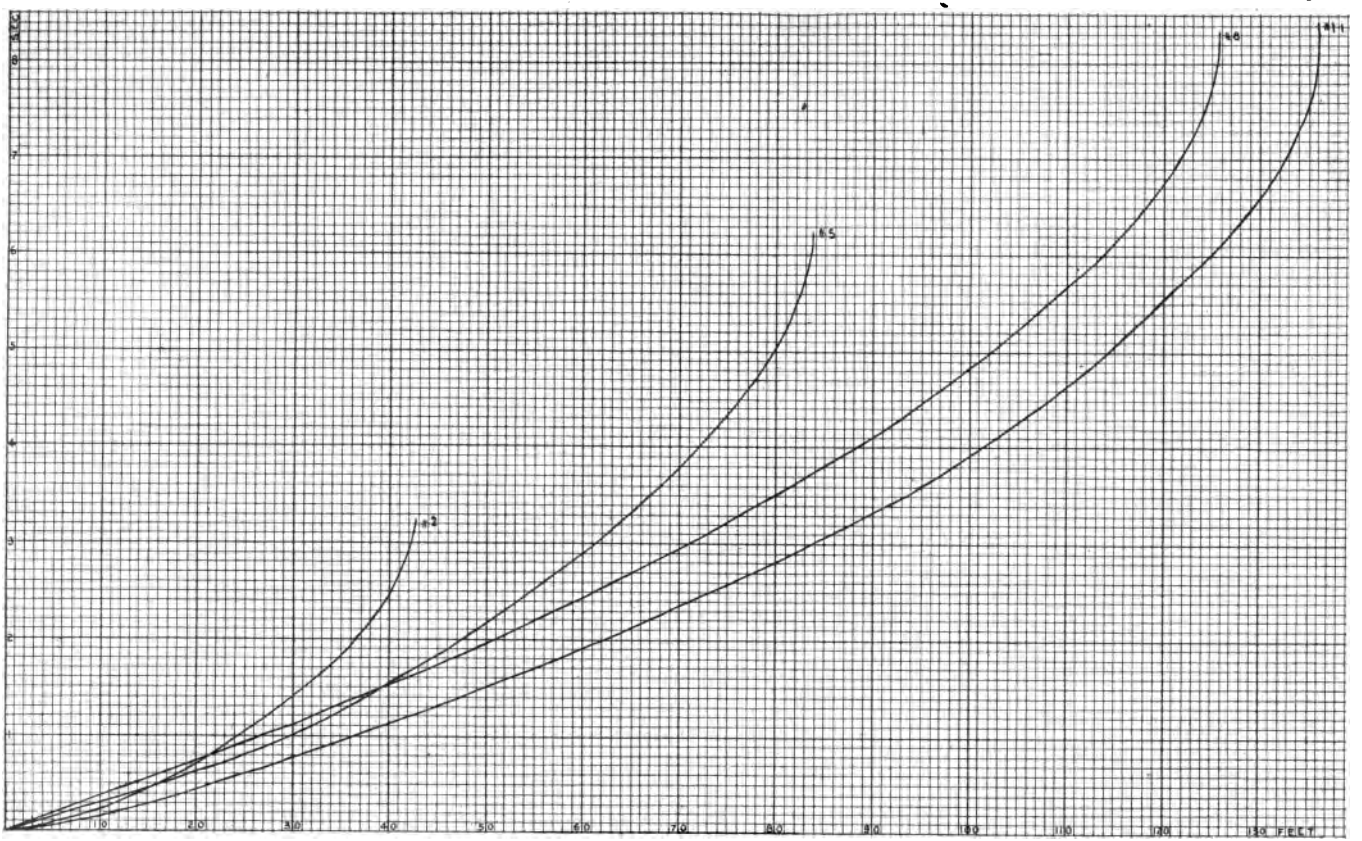

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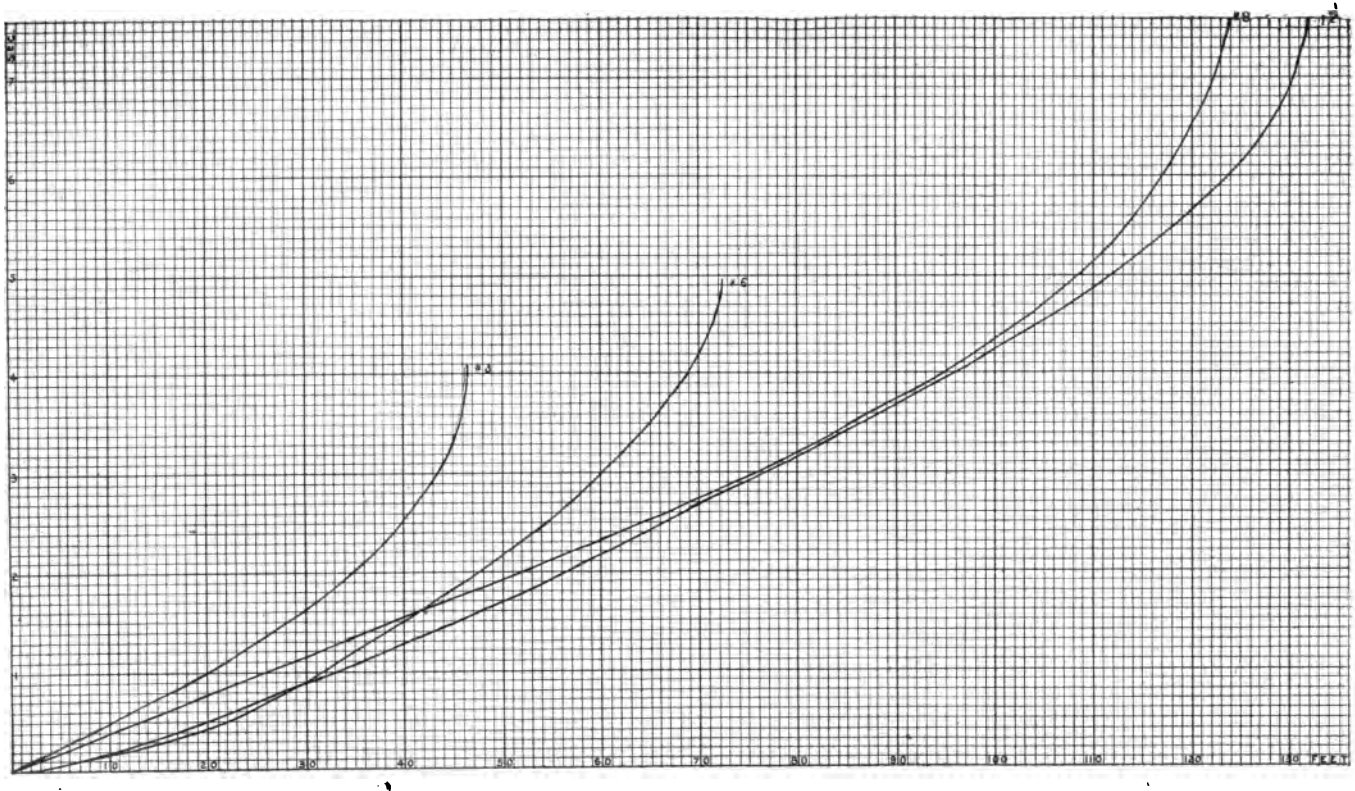

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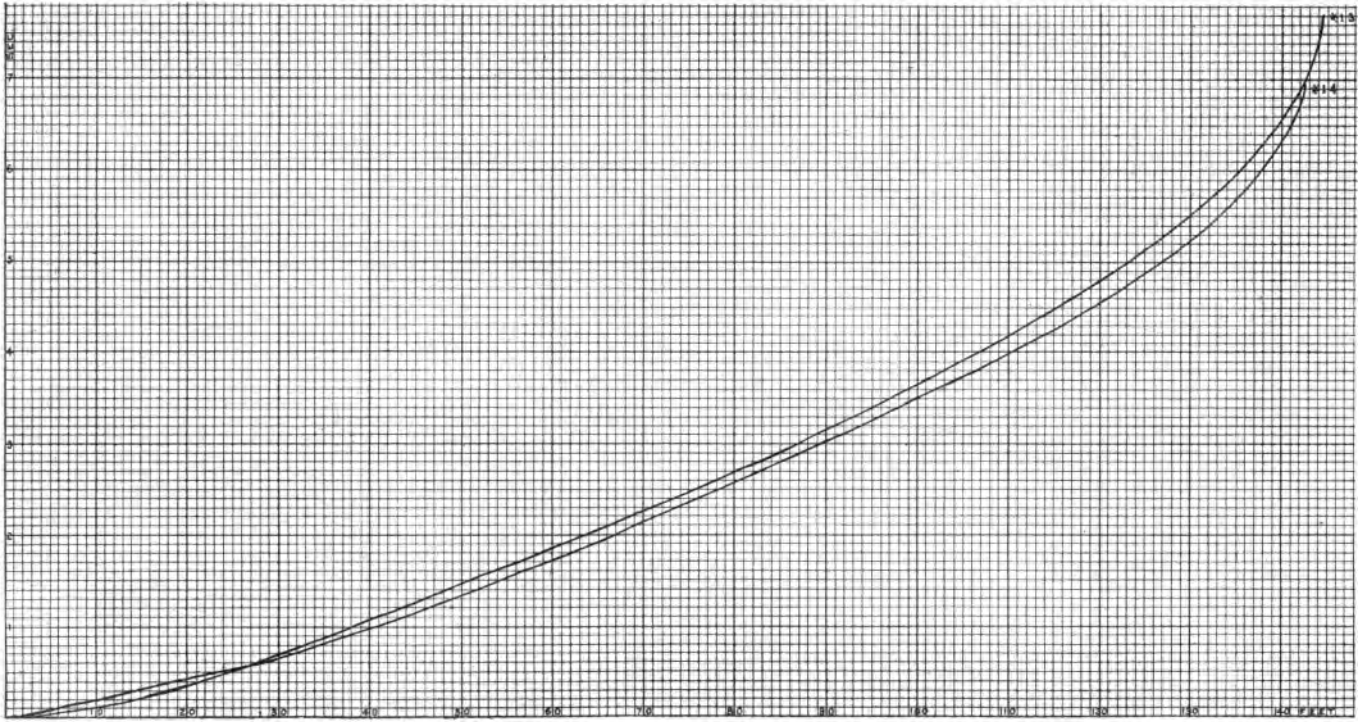

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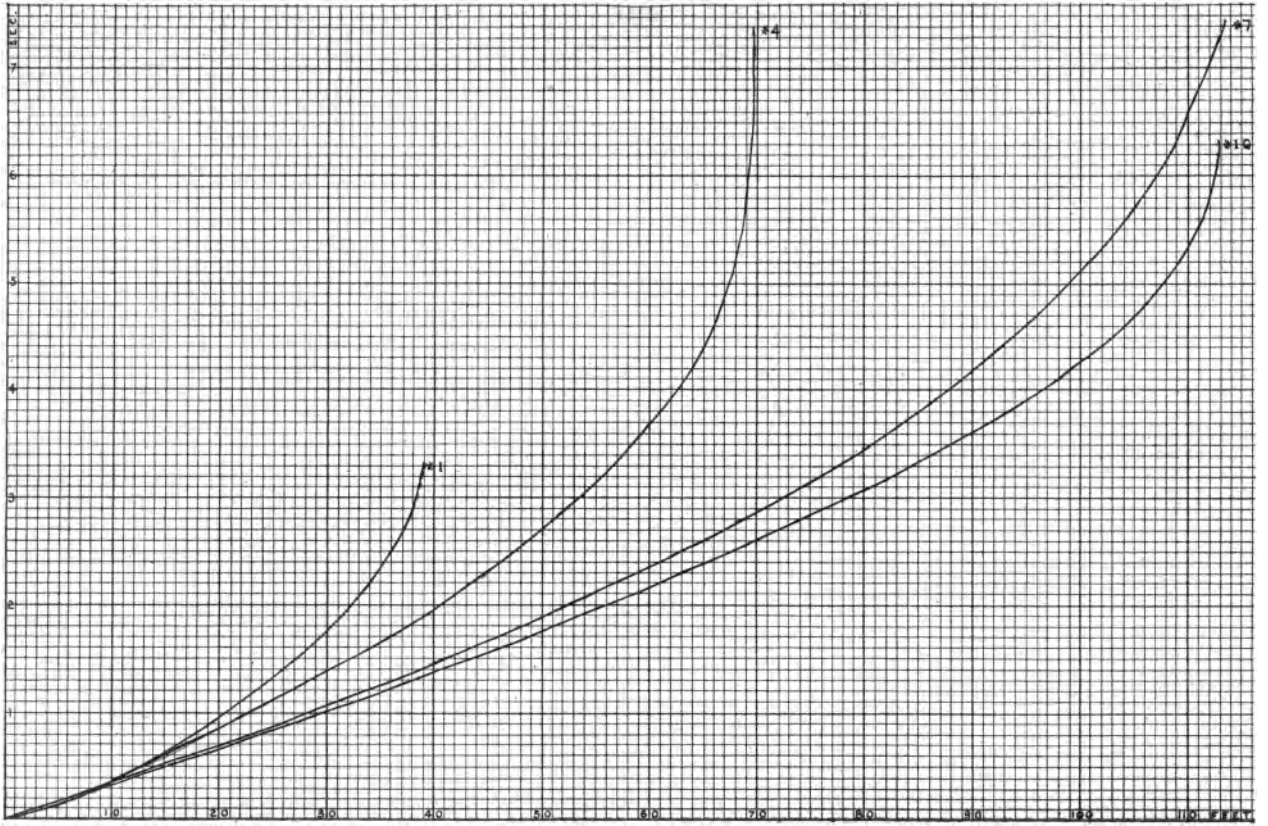

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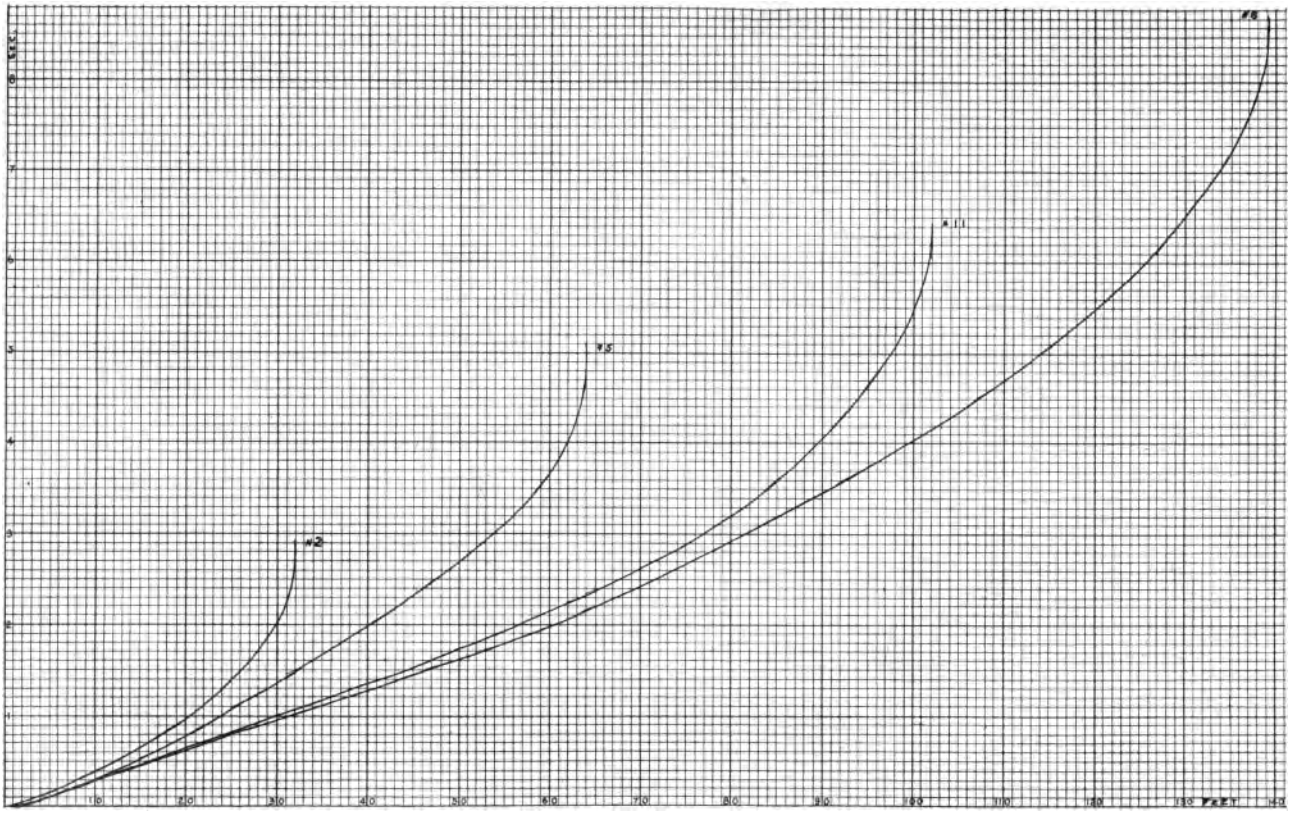

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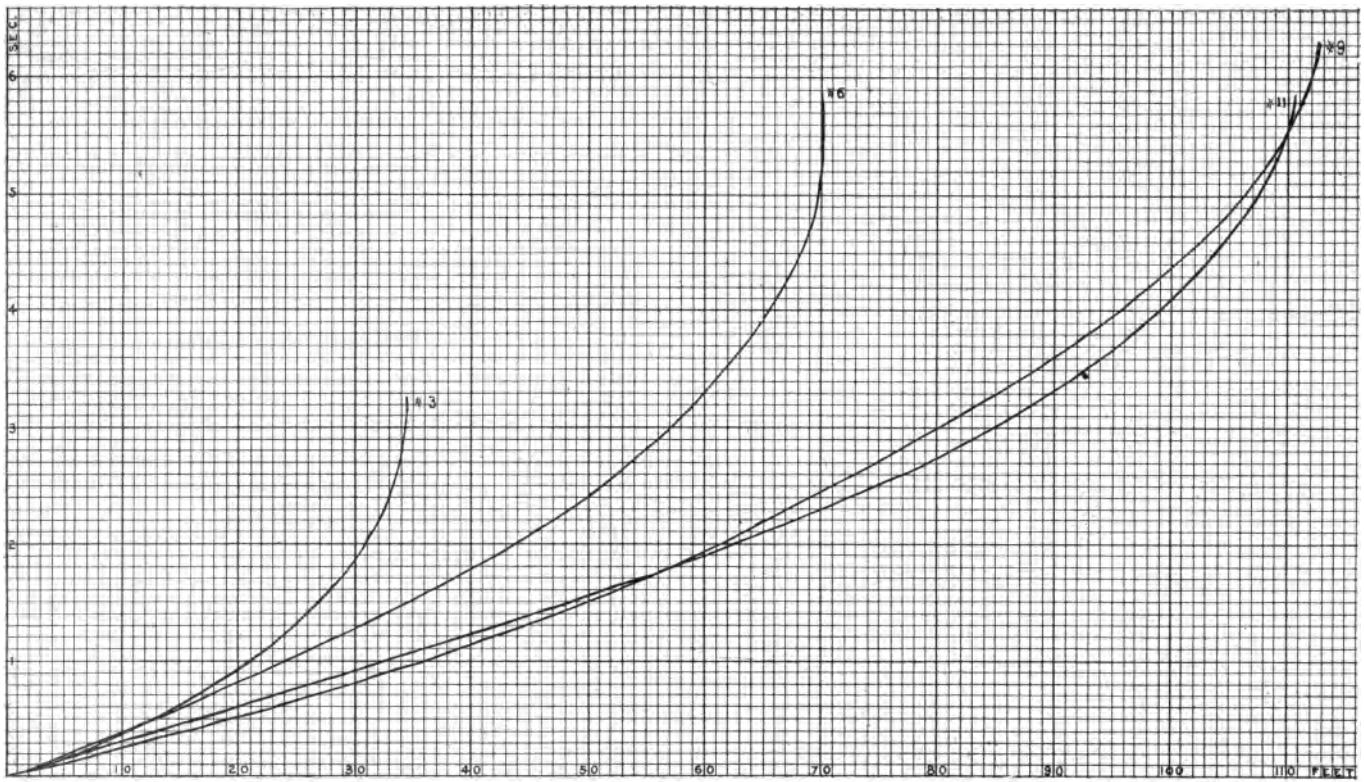

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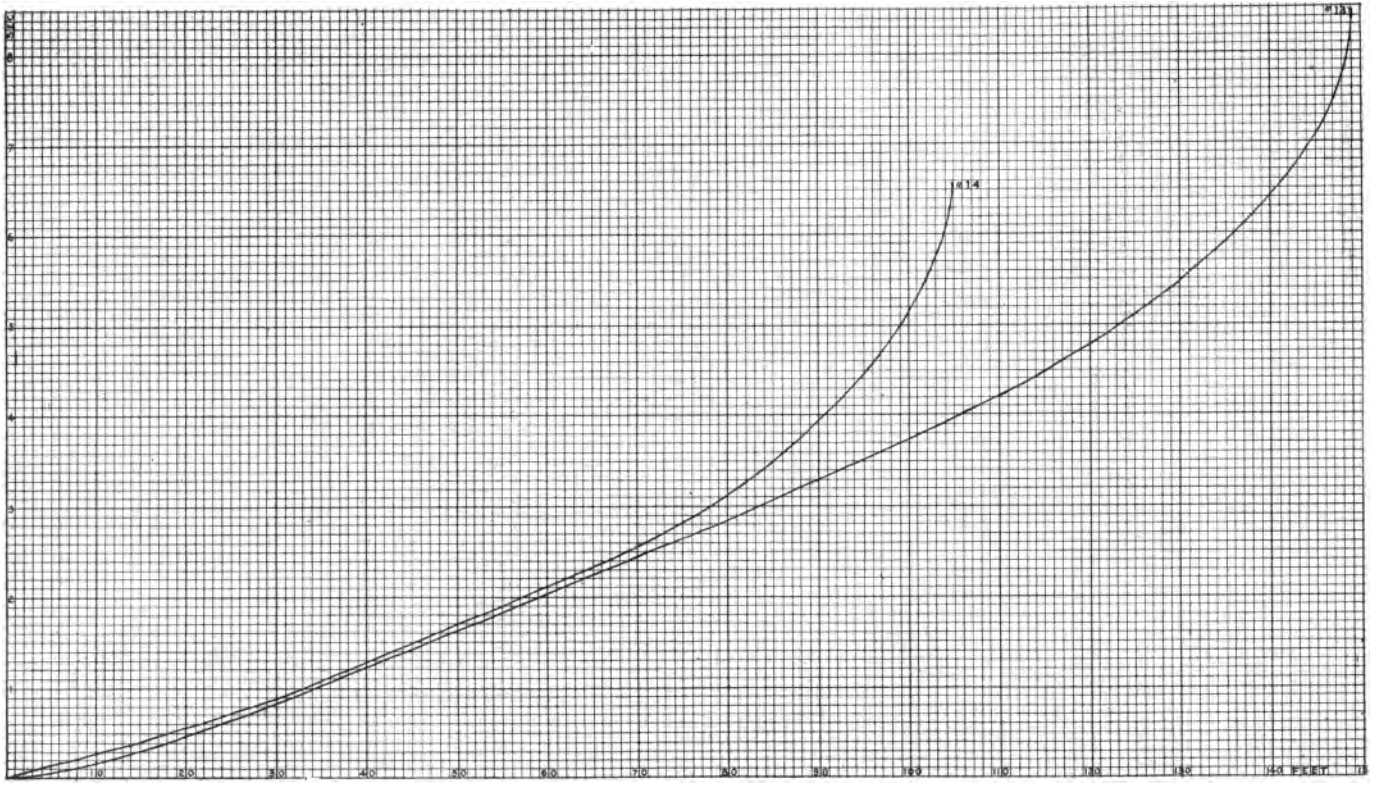

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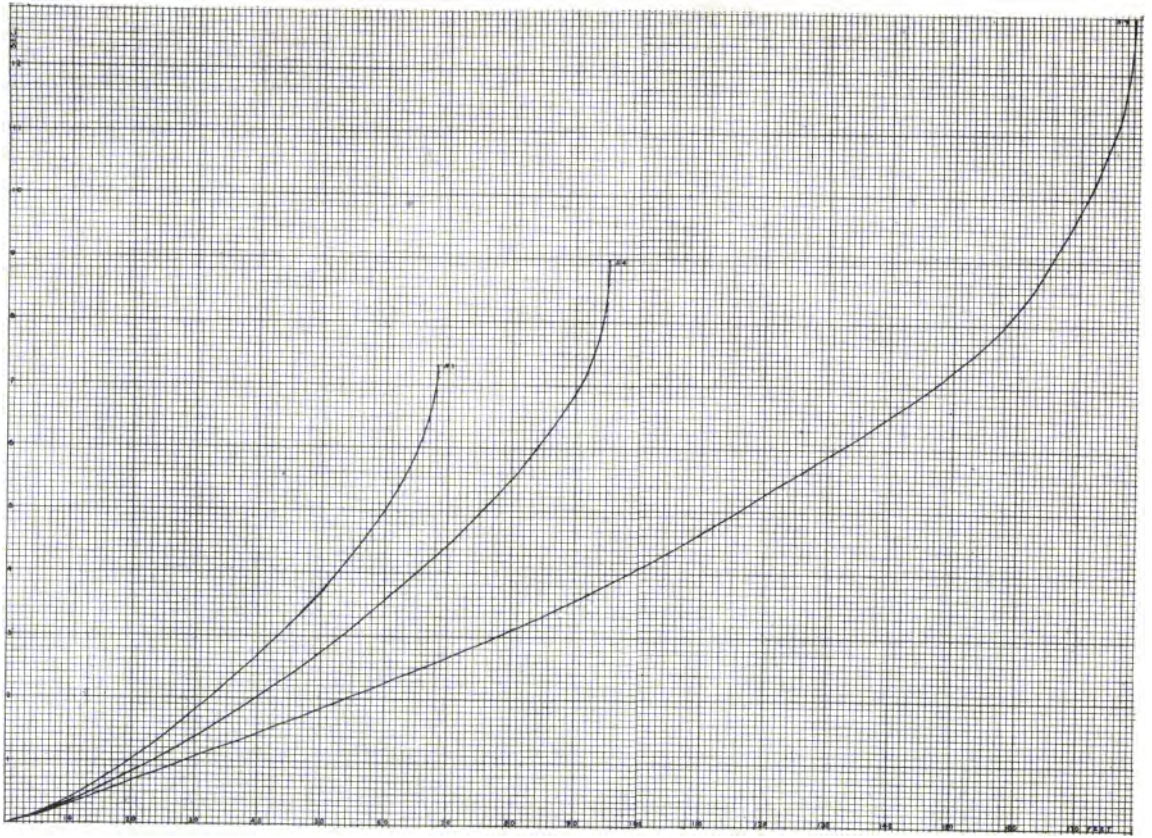

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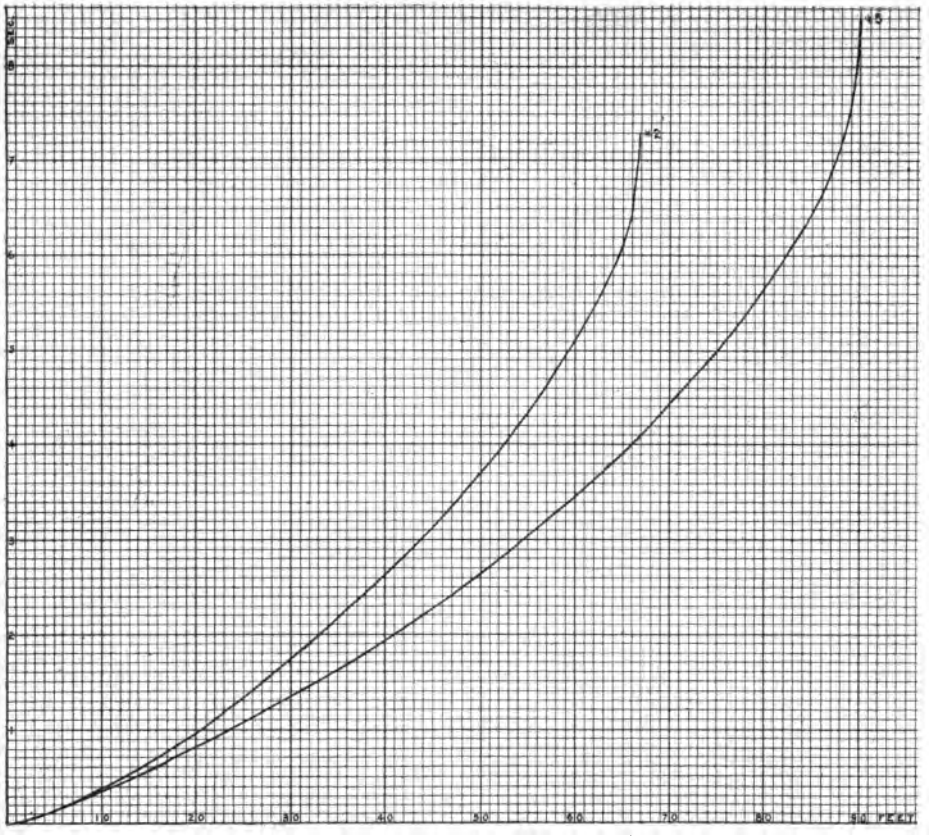

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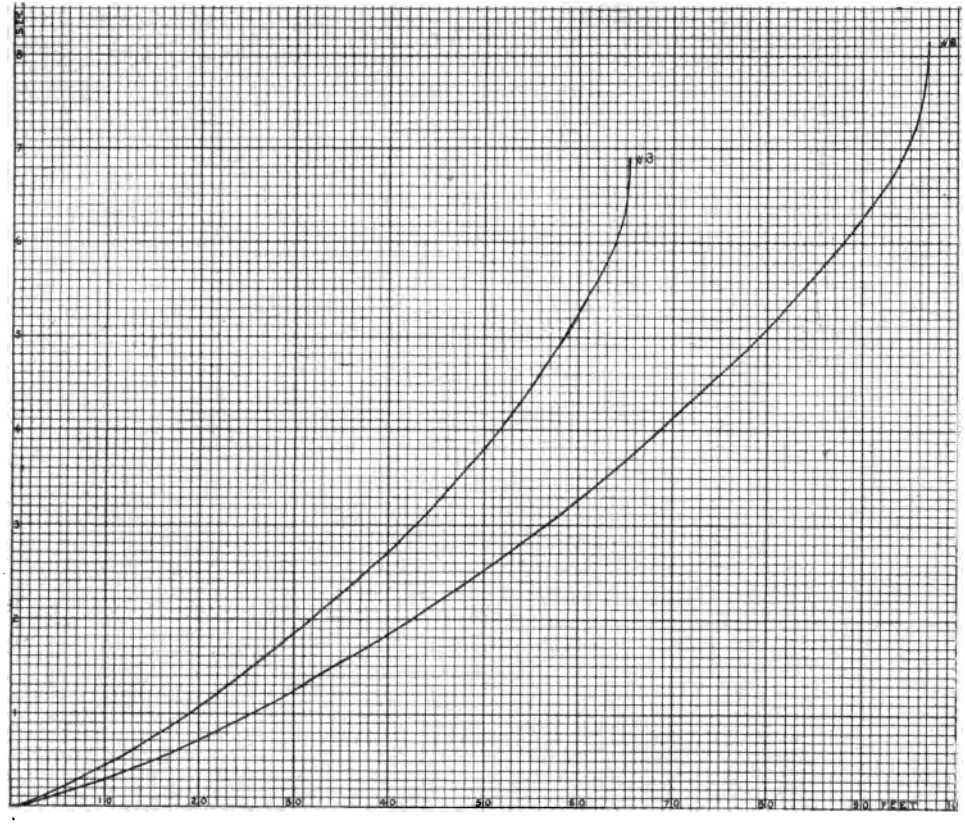

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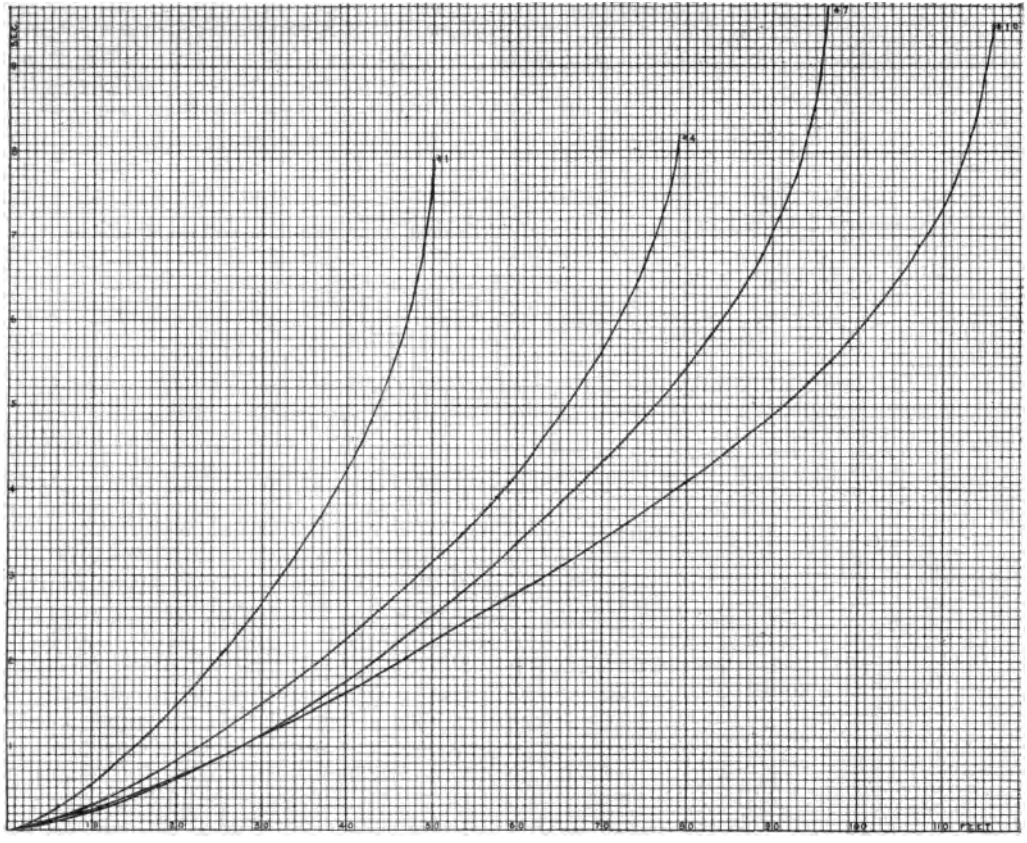

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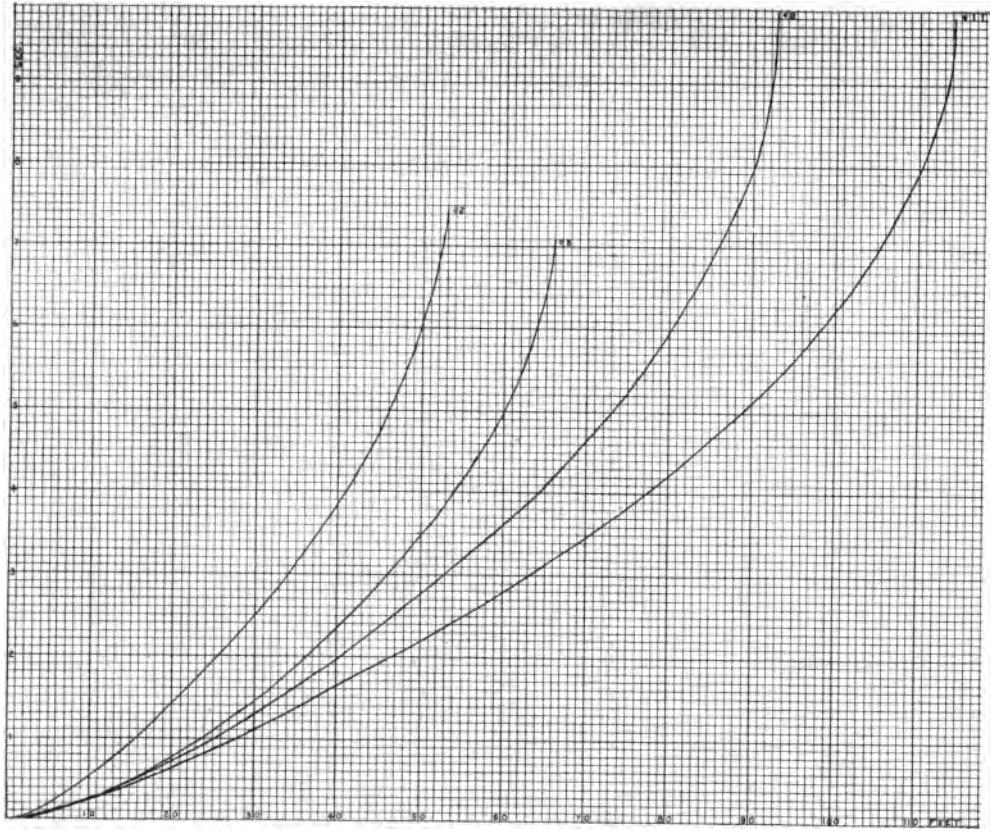

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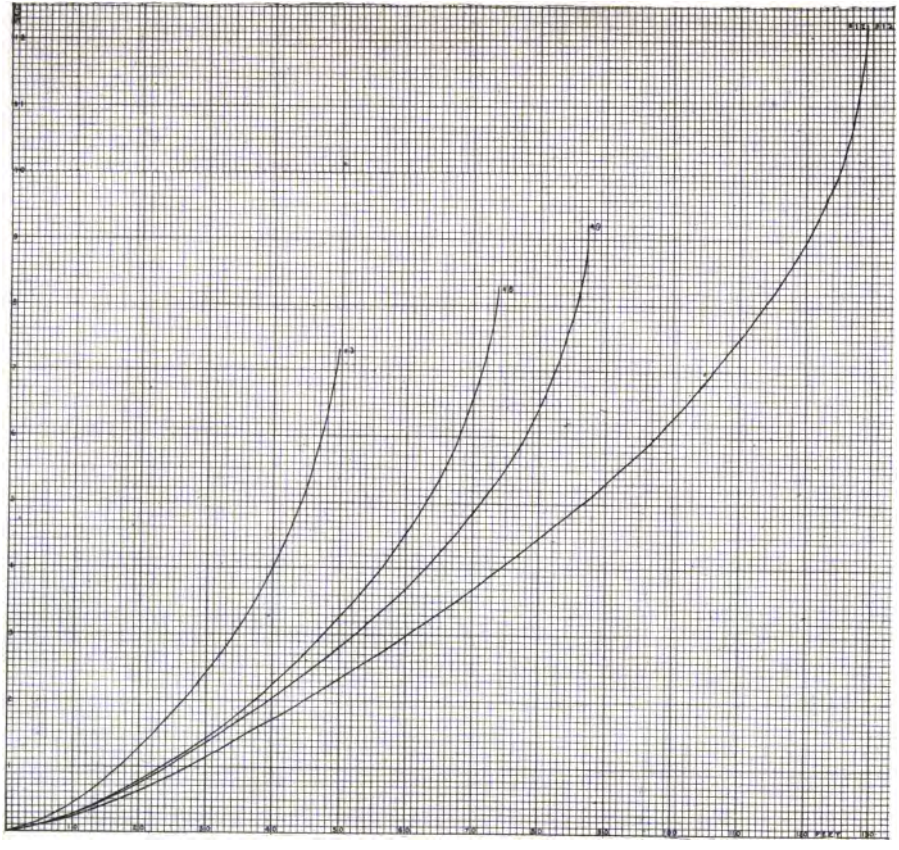

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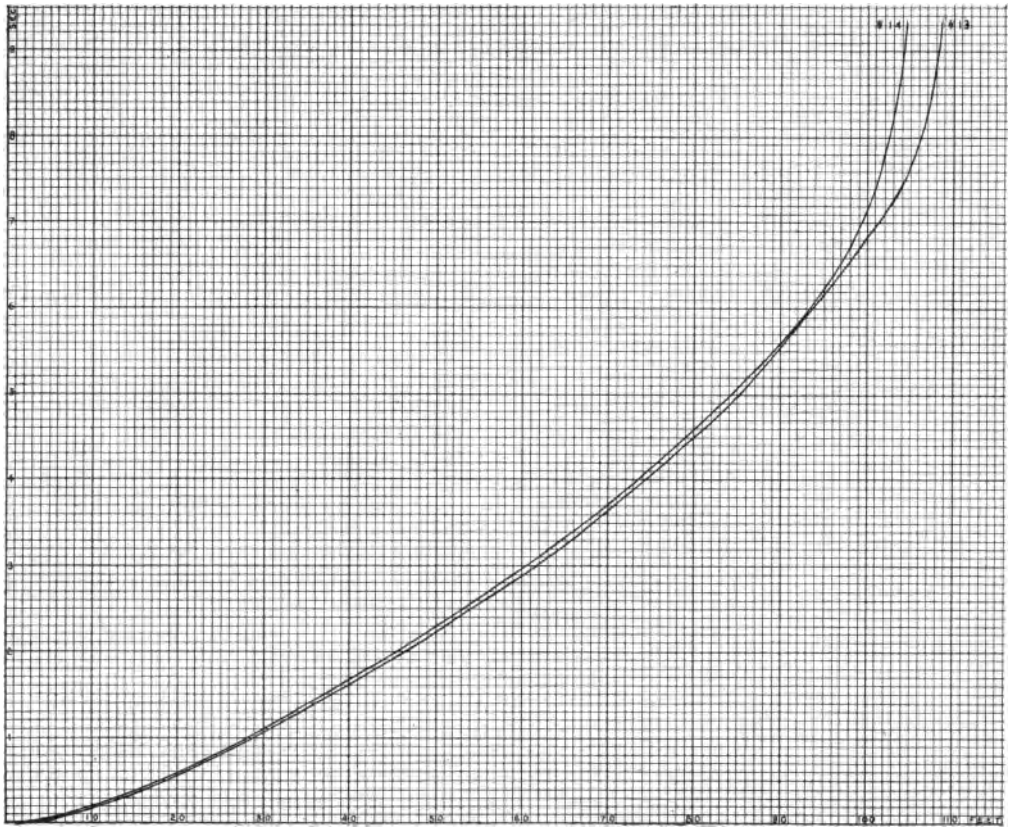

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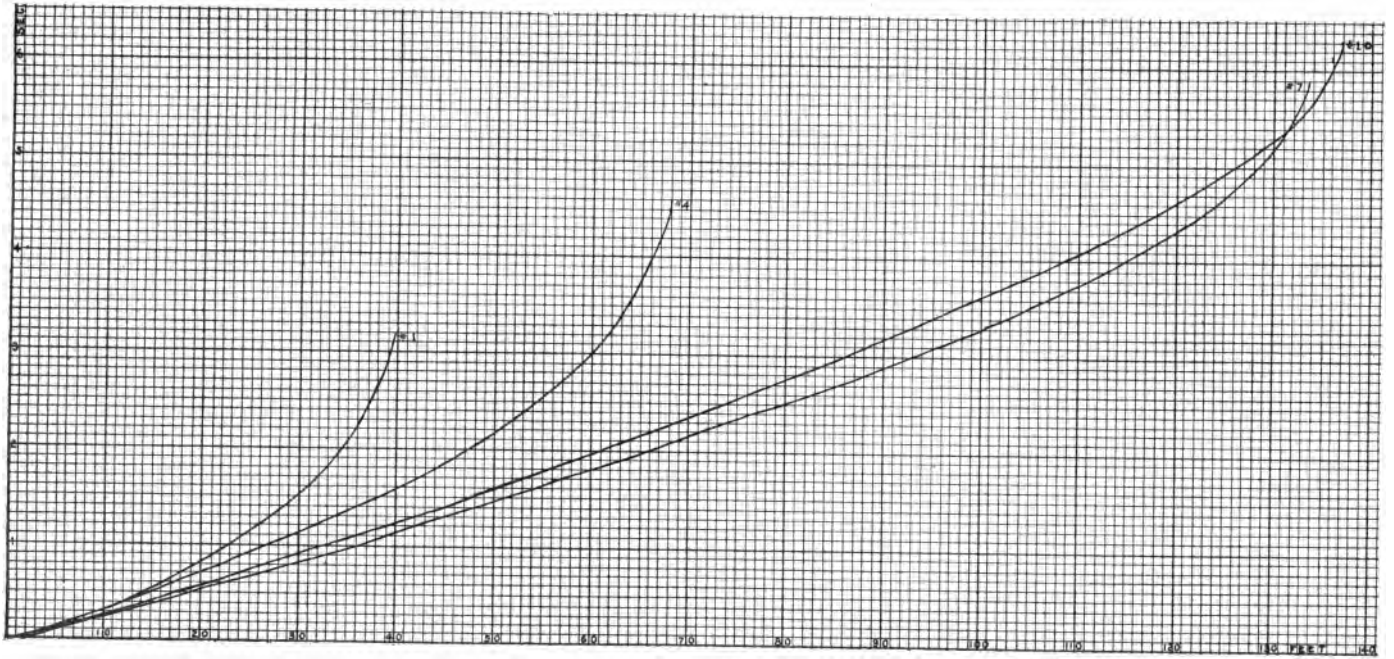

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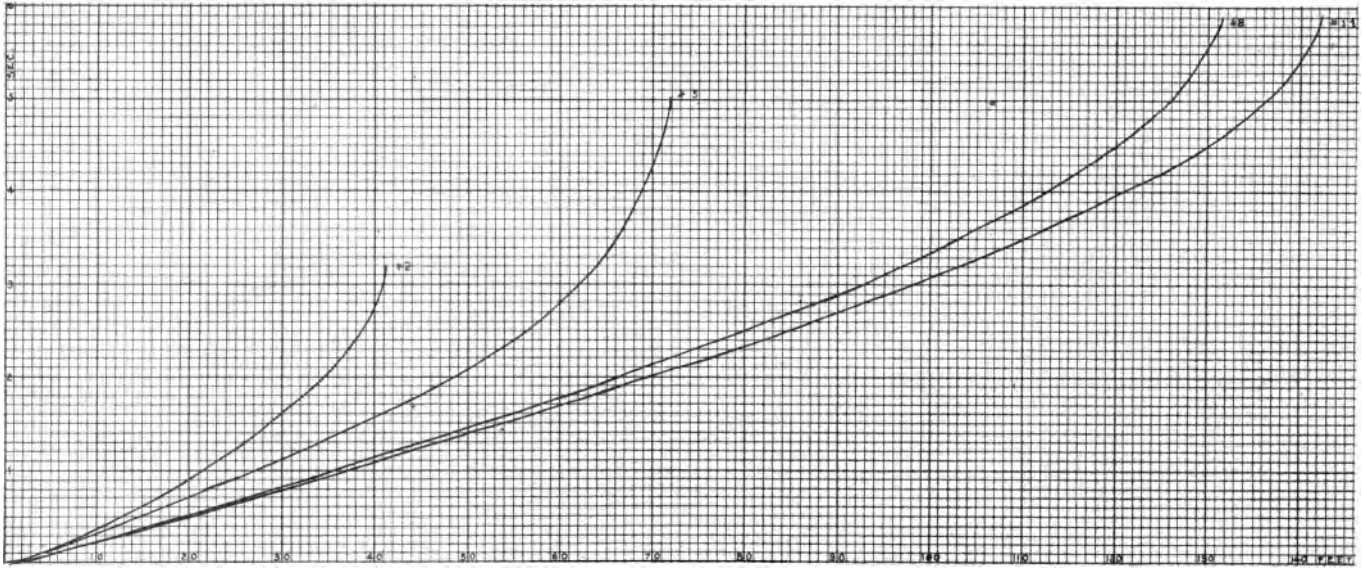

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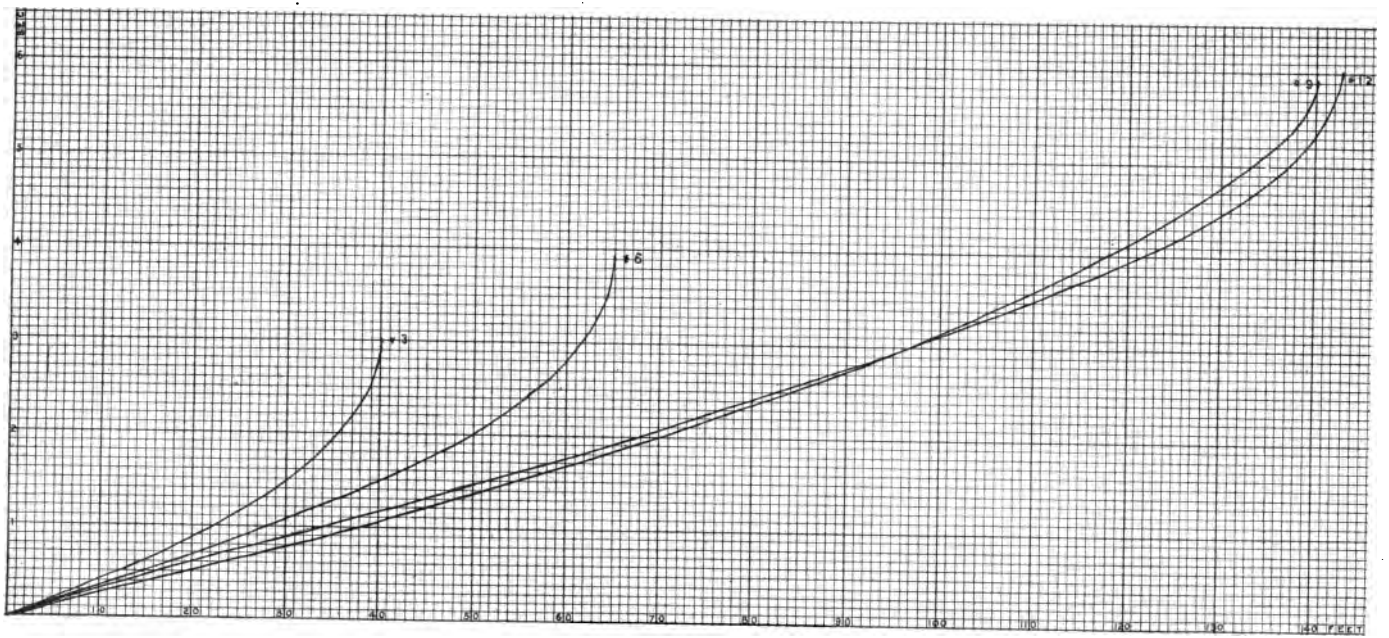

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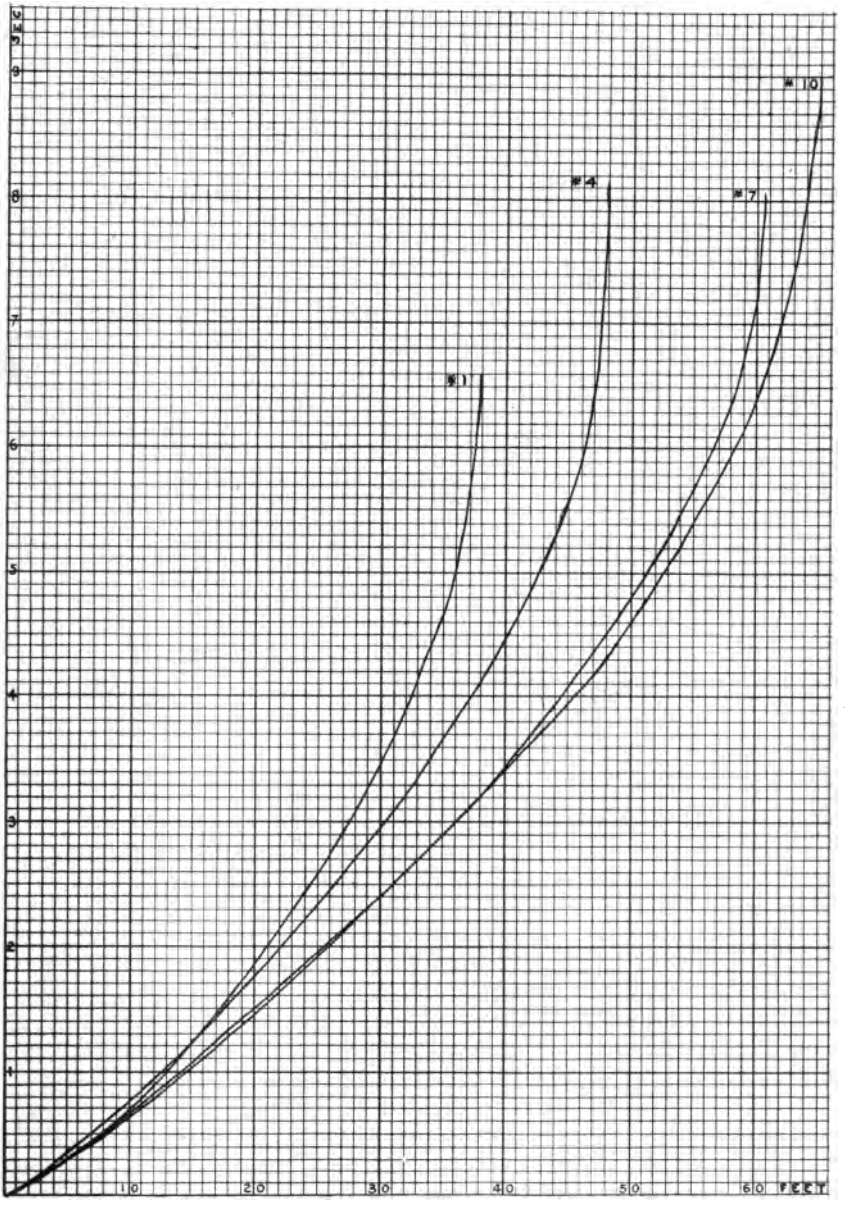

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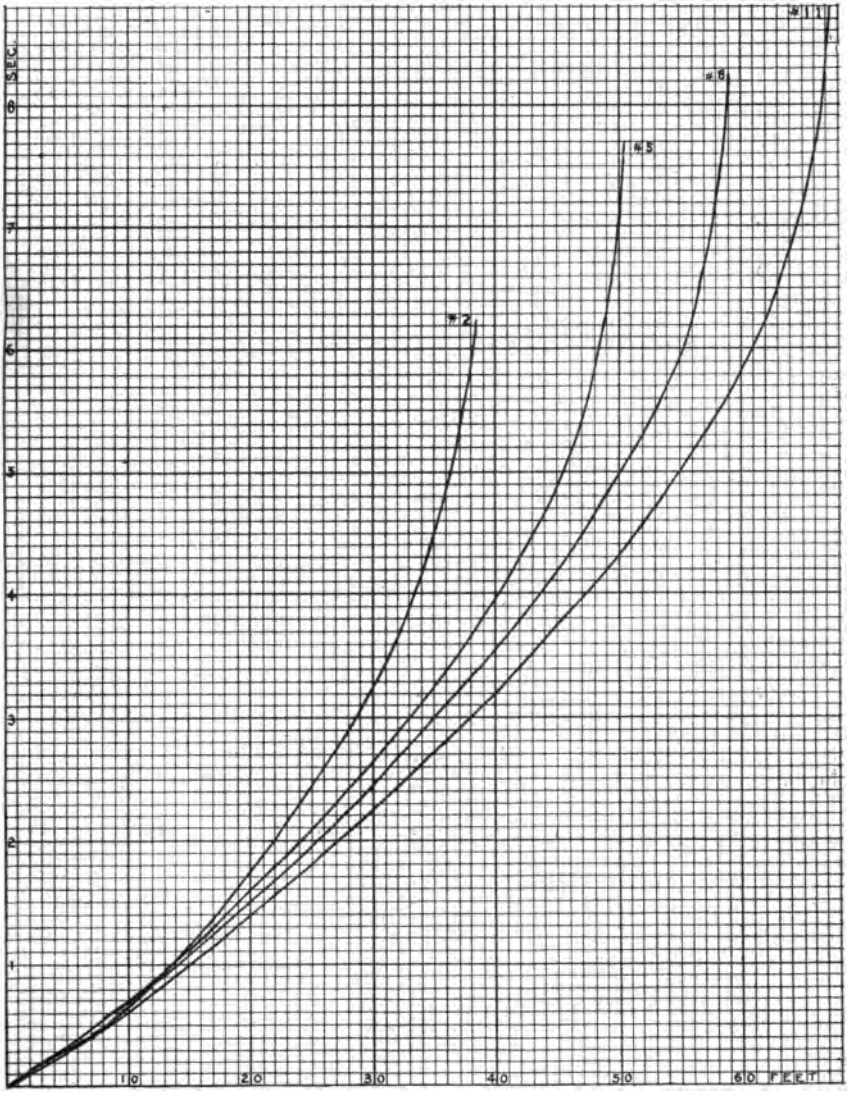

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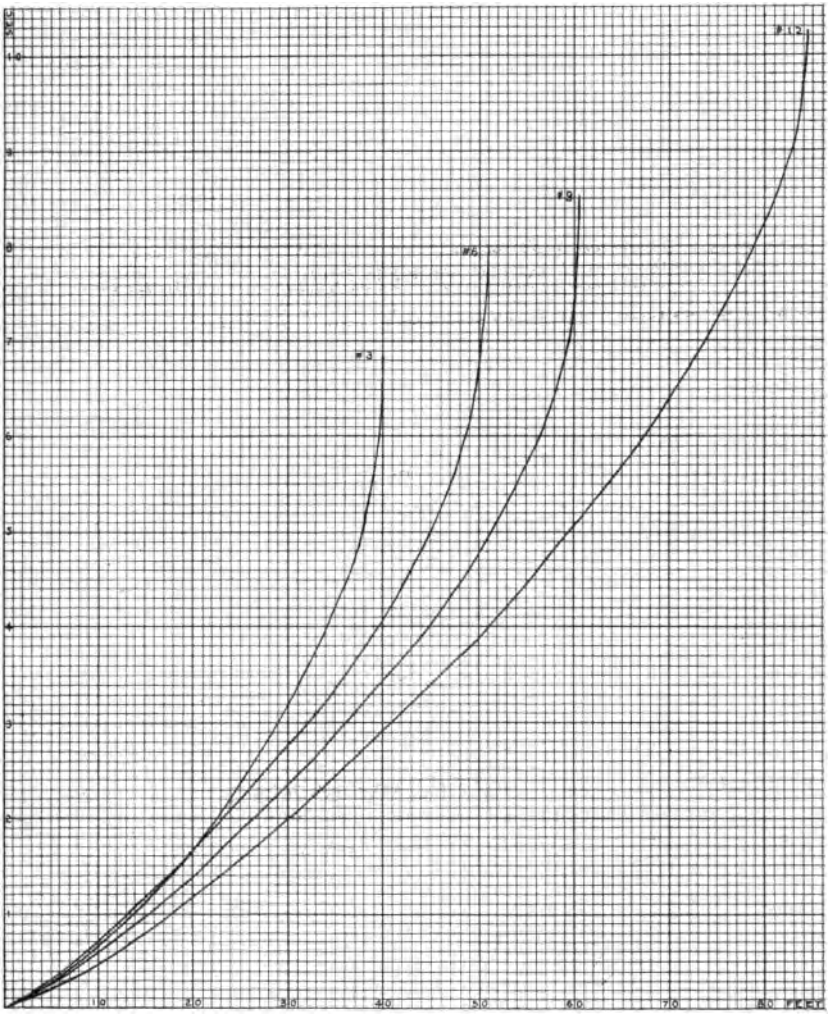

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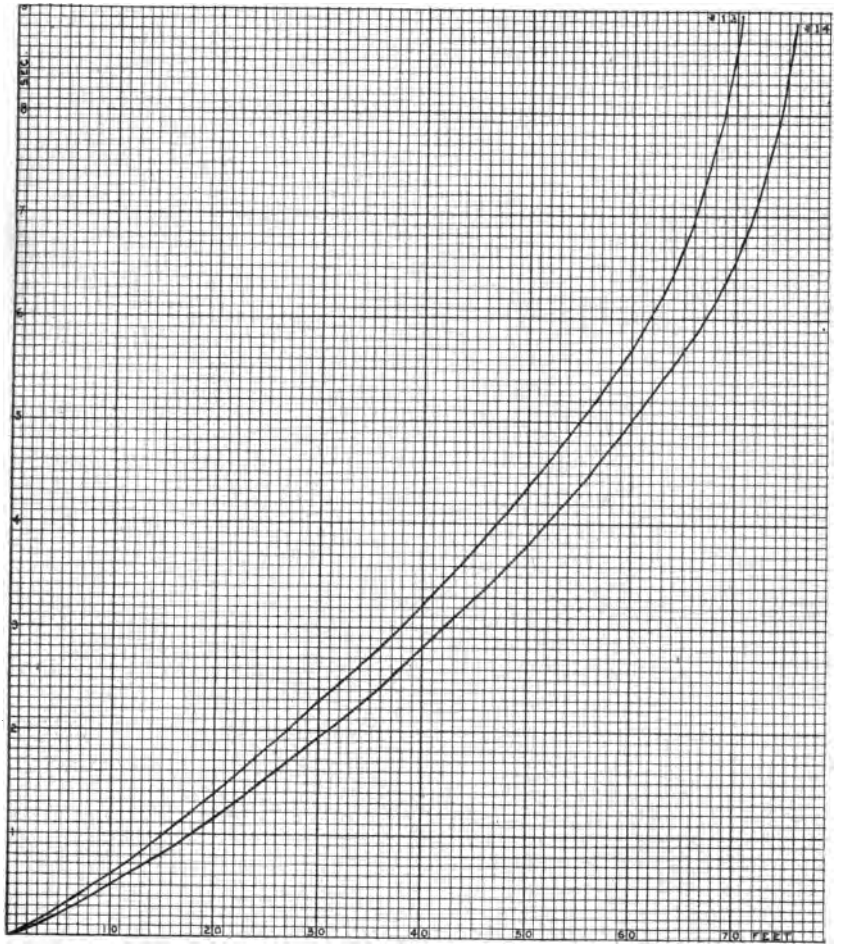

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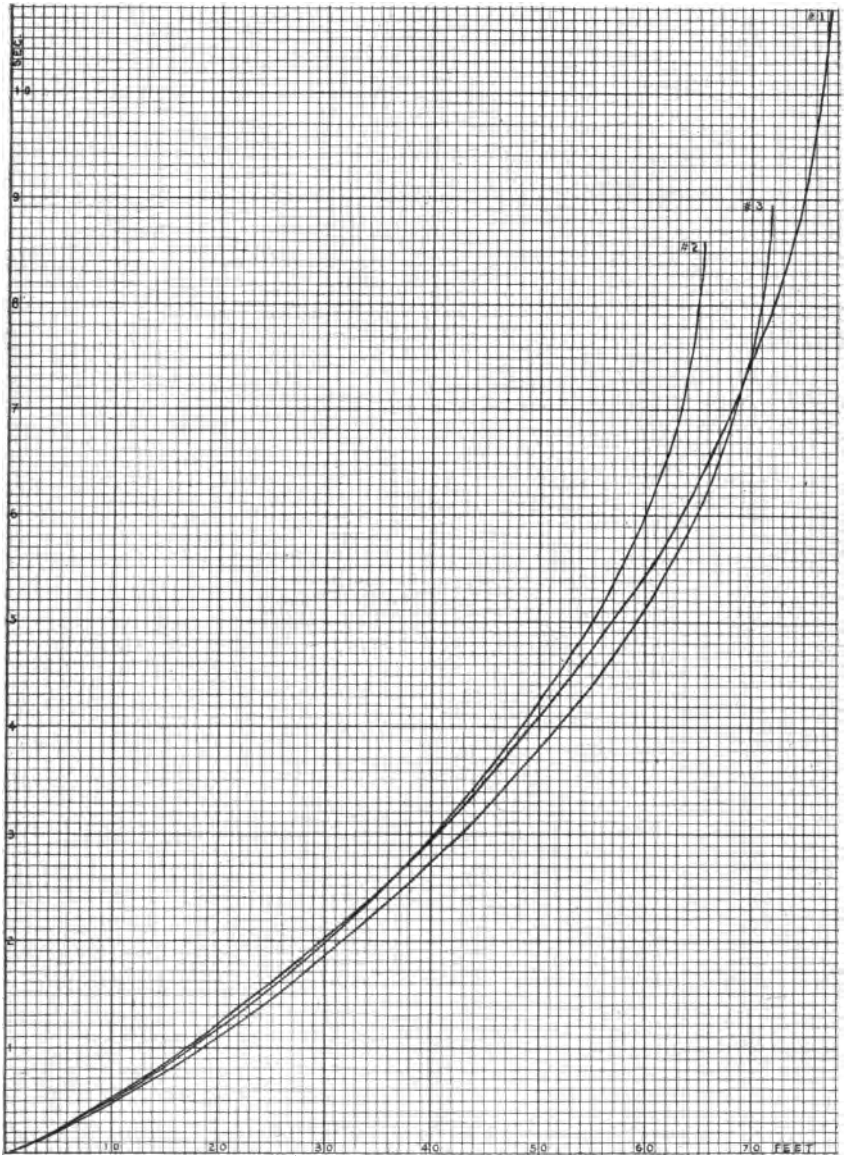

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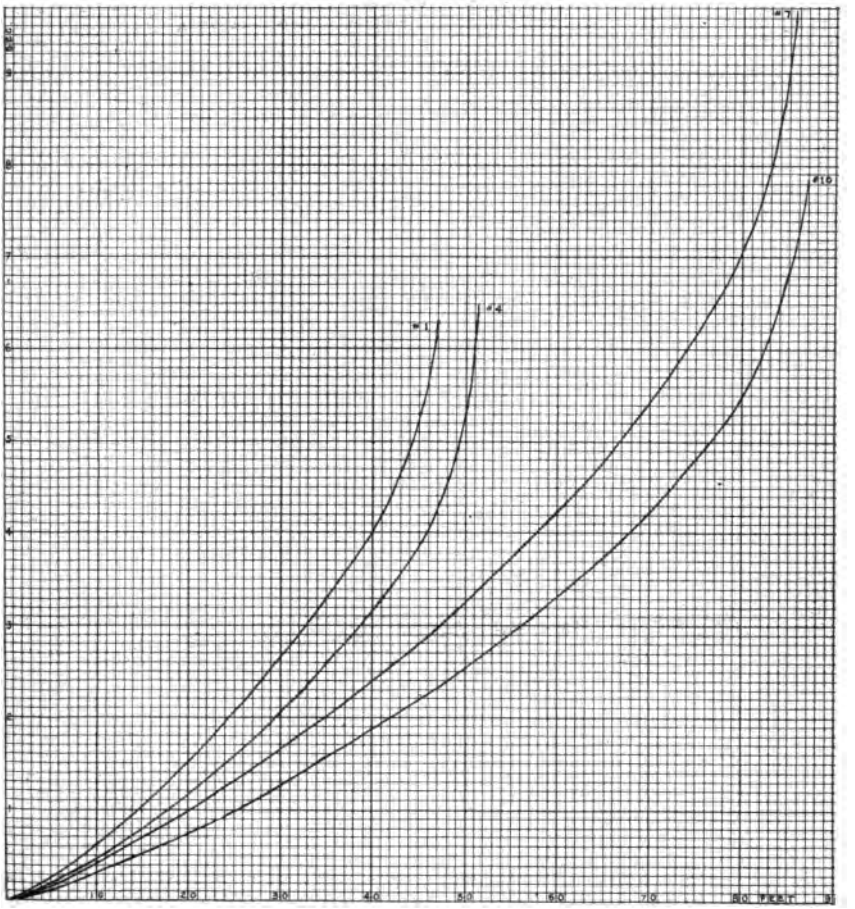

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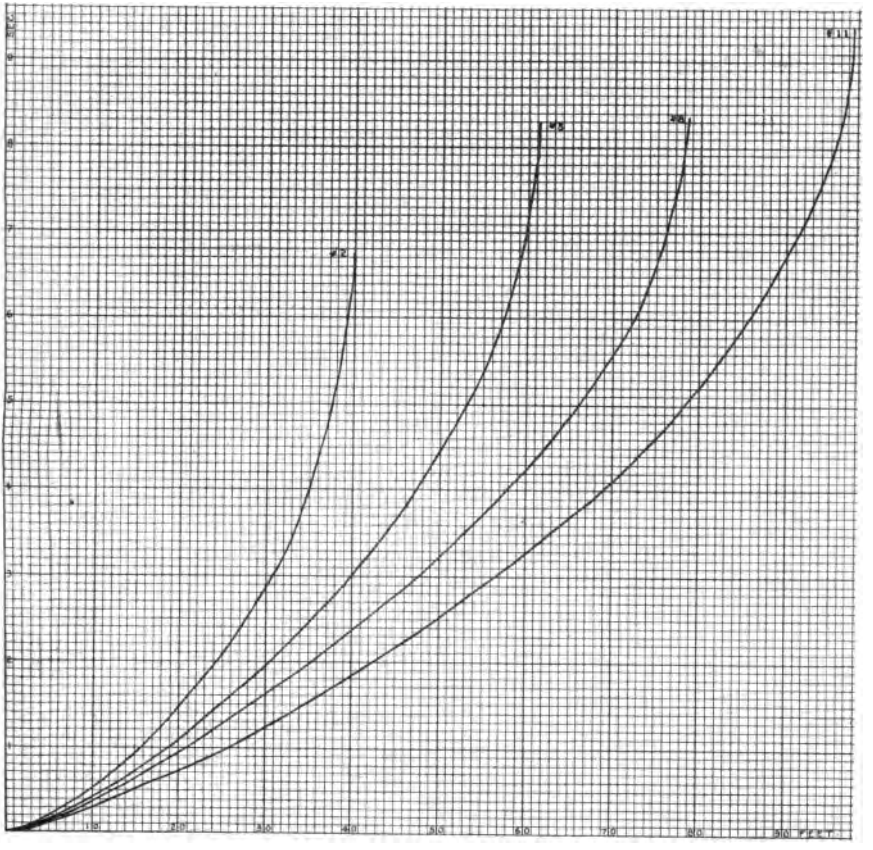

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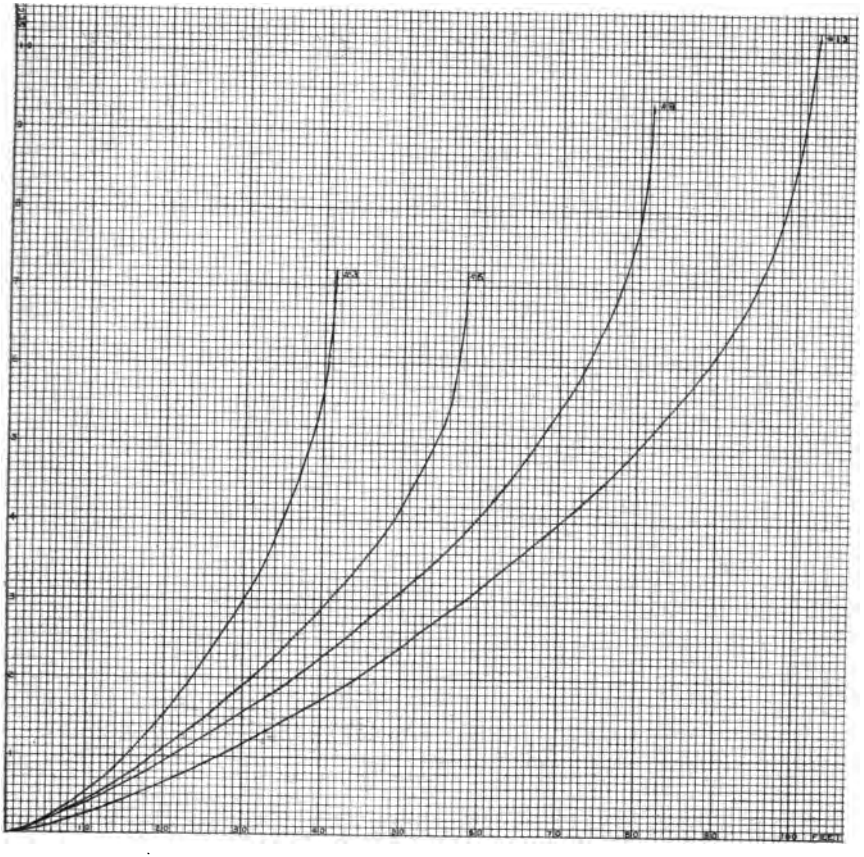

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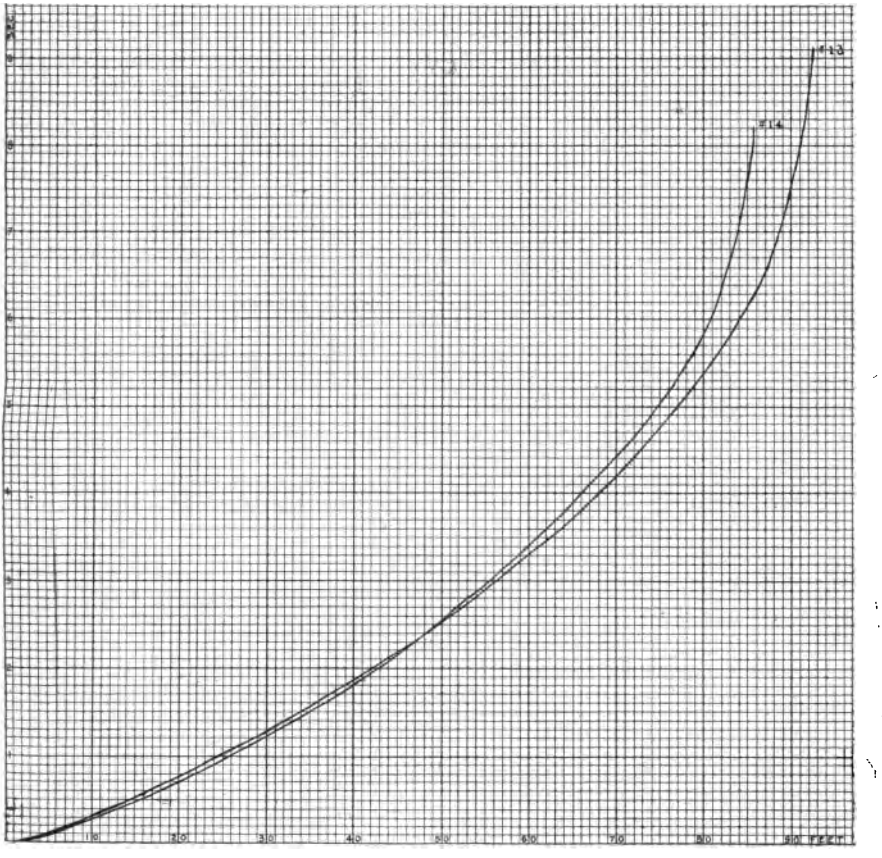

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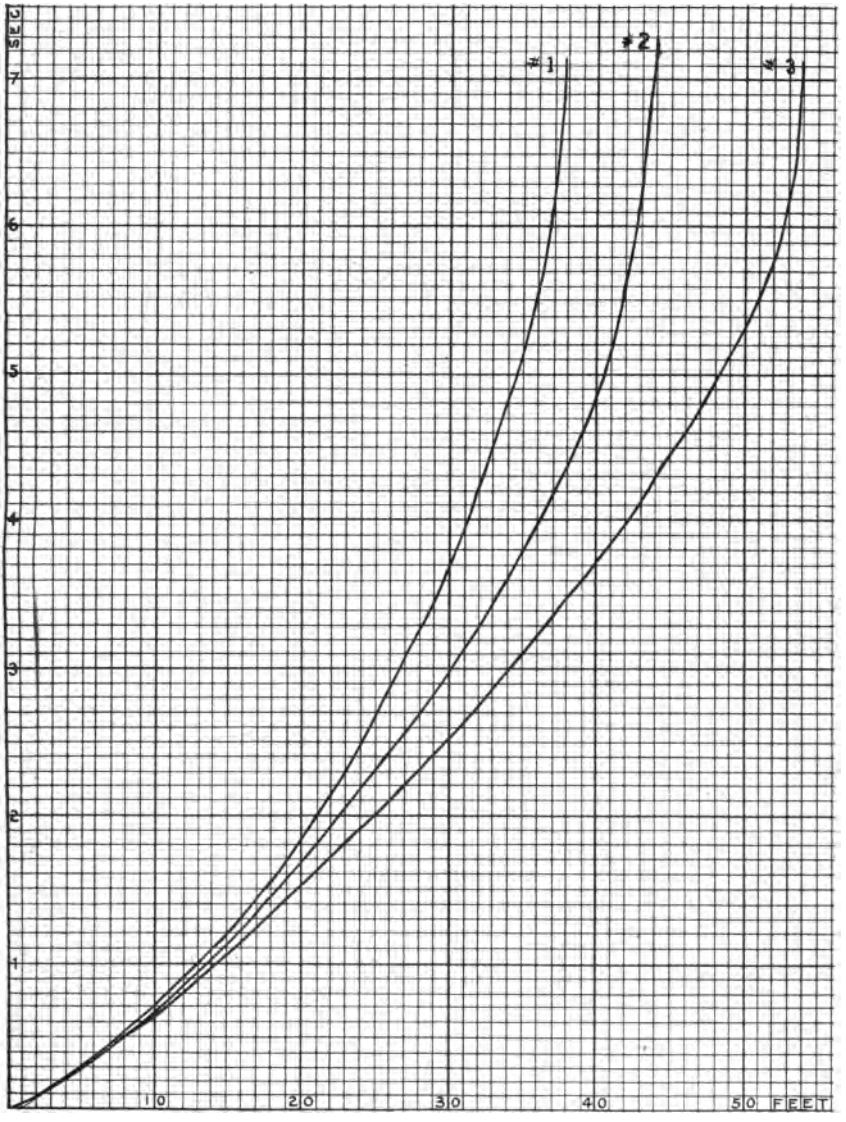

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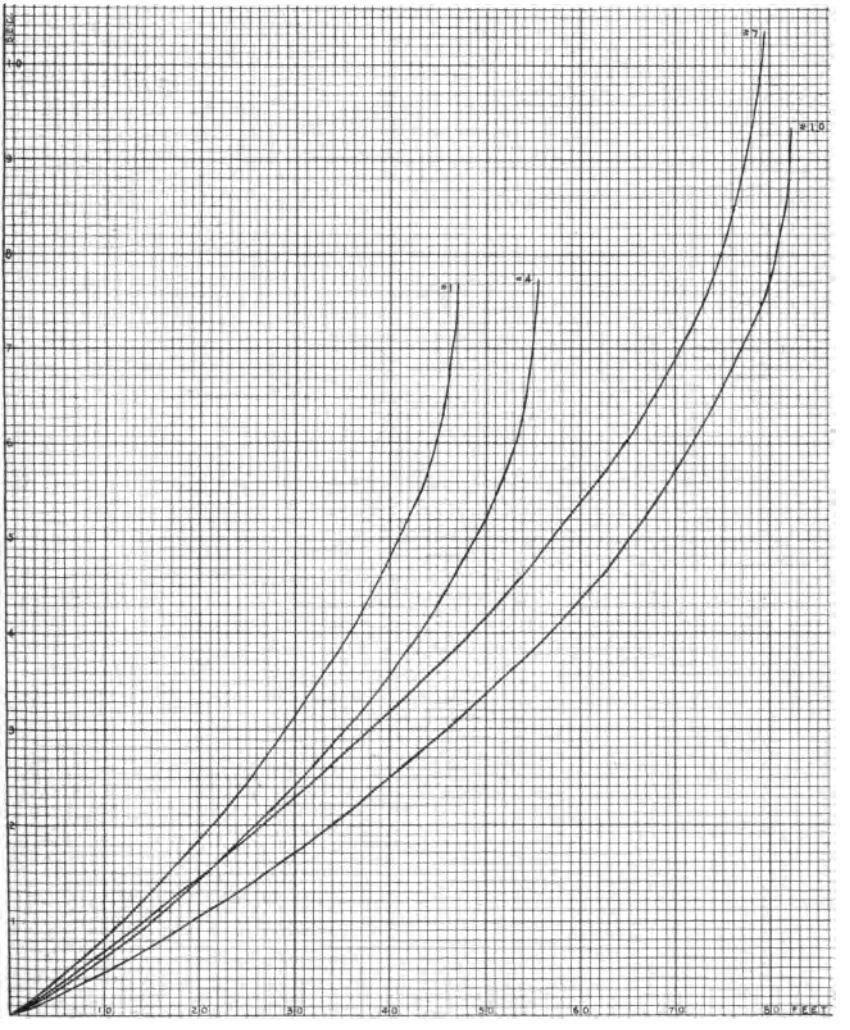

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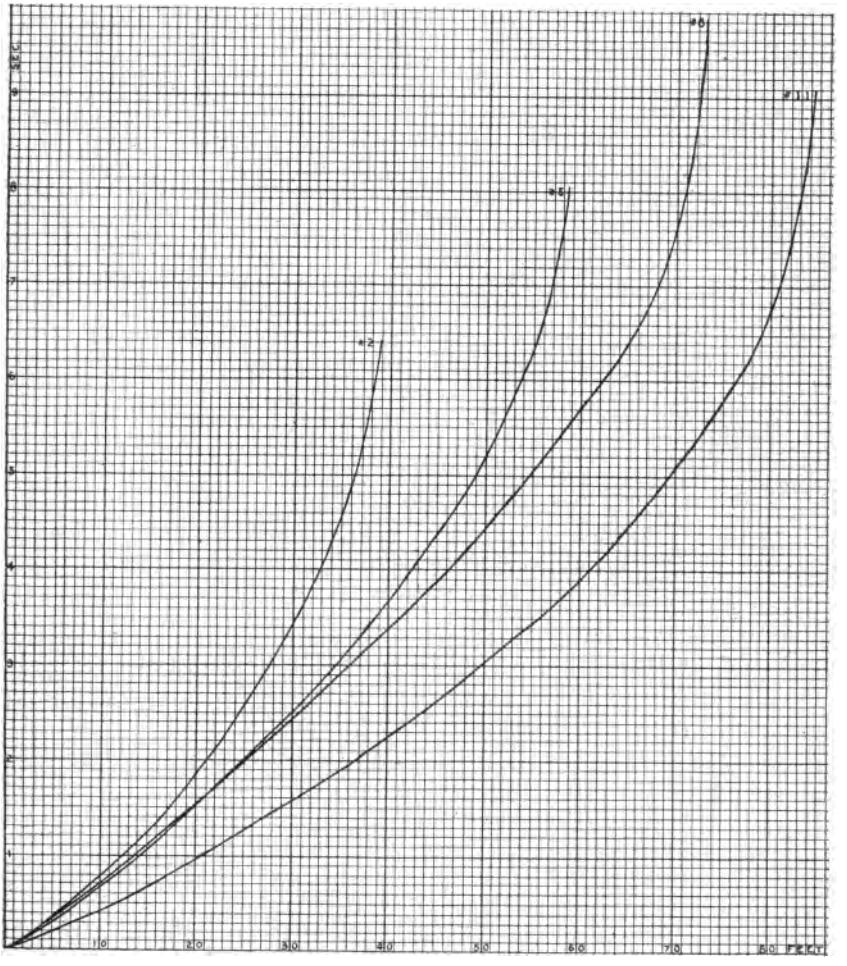

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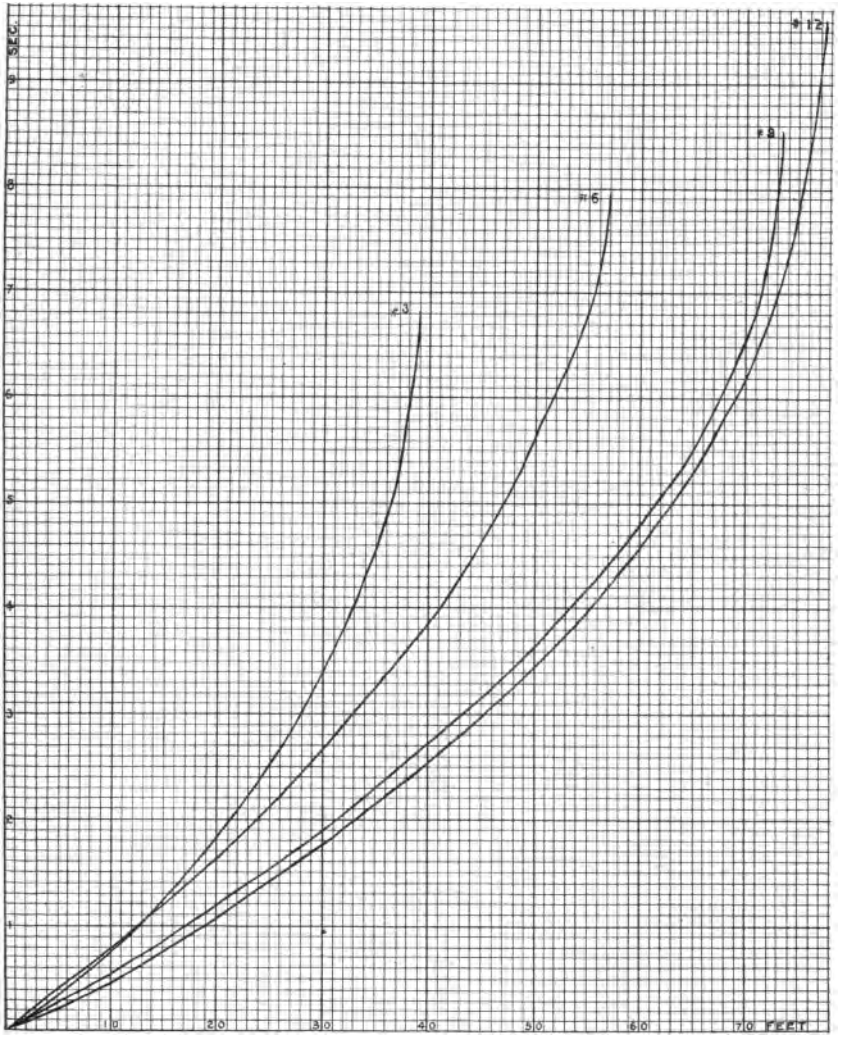

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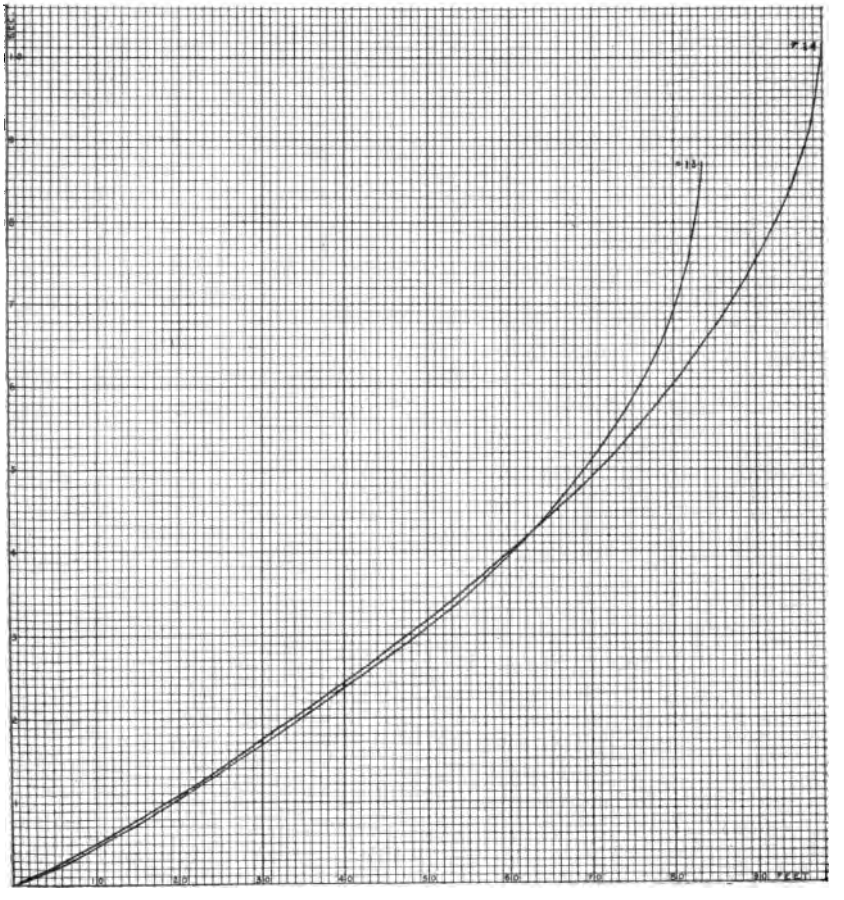
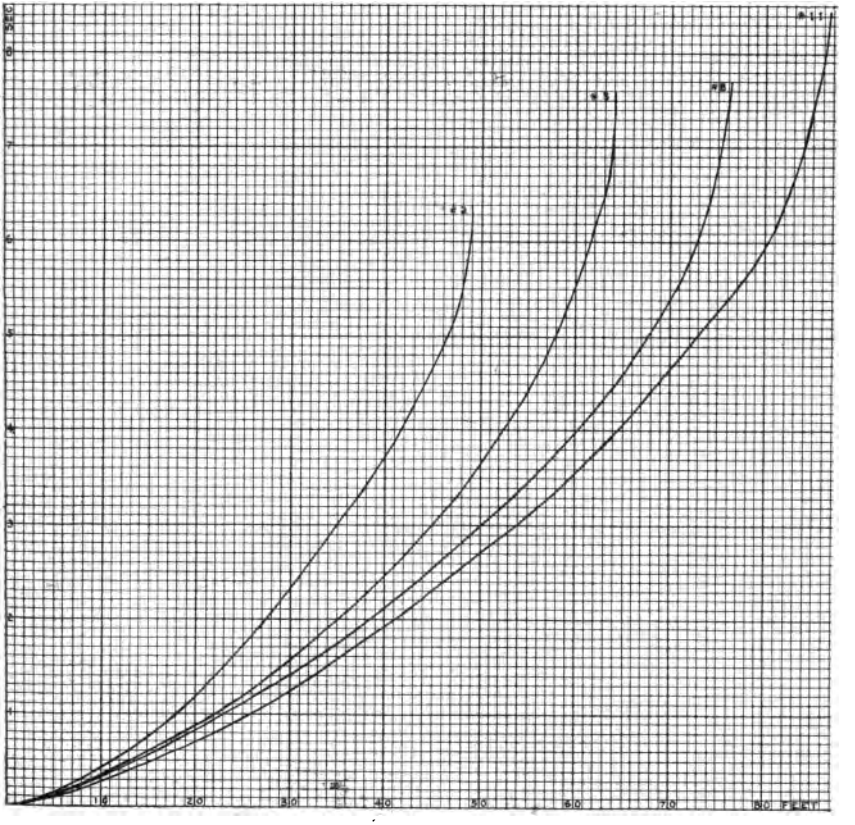


Cross-section Sheet No. 58.

Cross-section Sheet No. 59.



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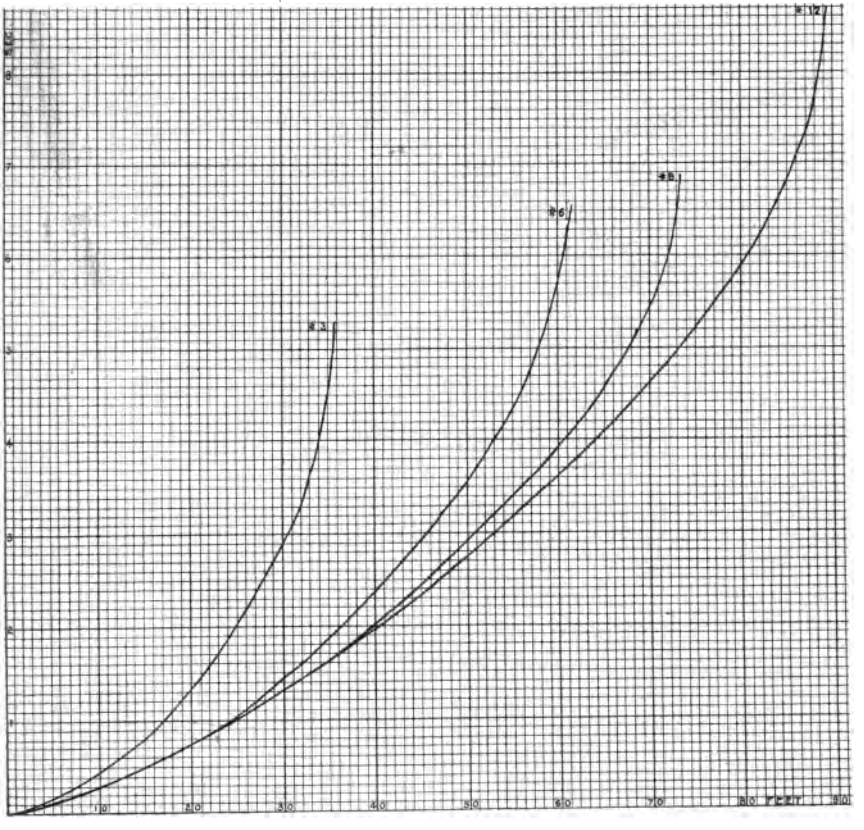

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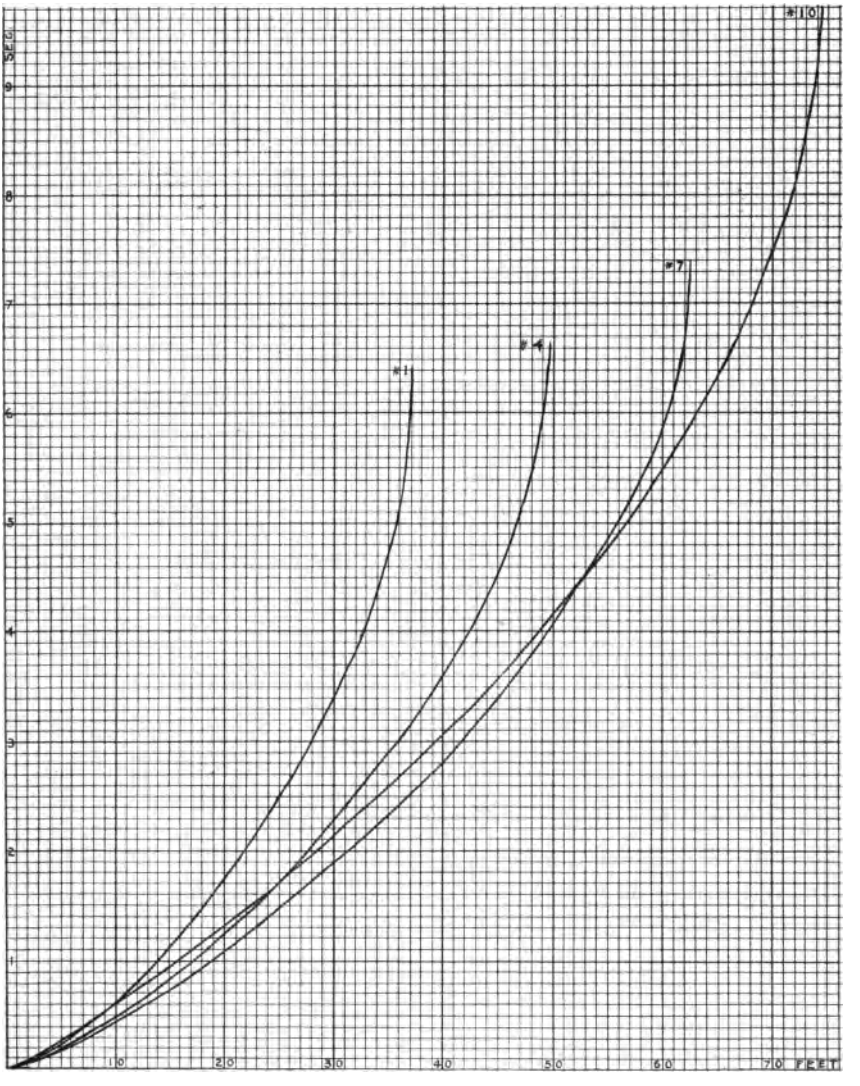

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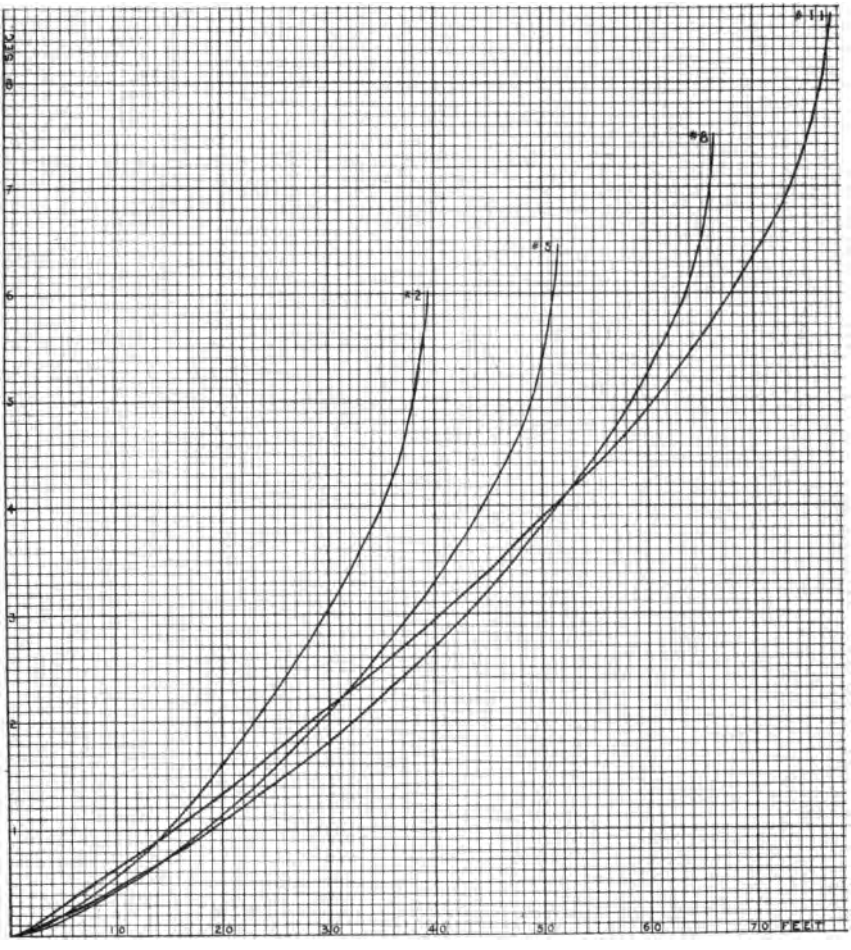

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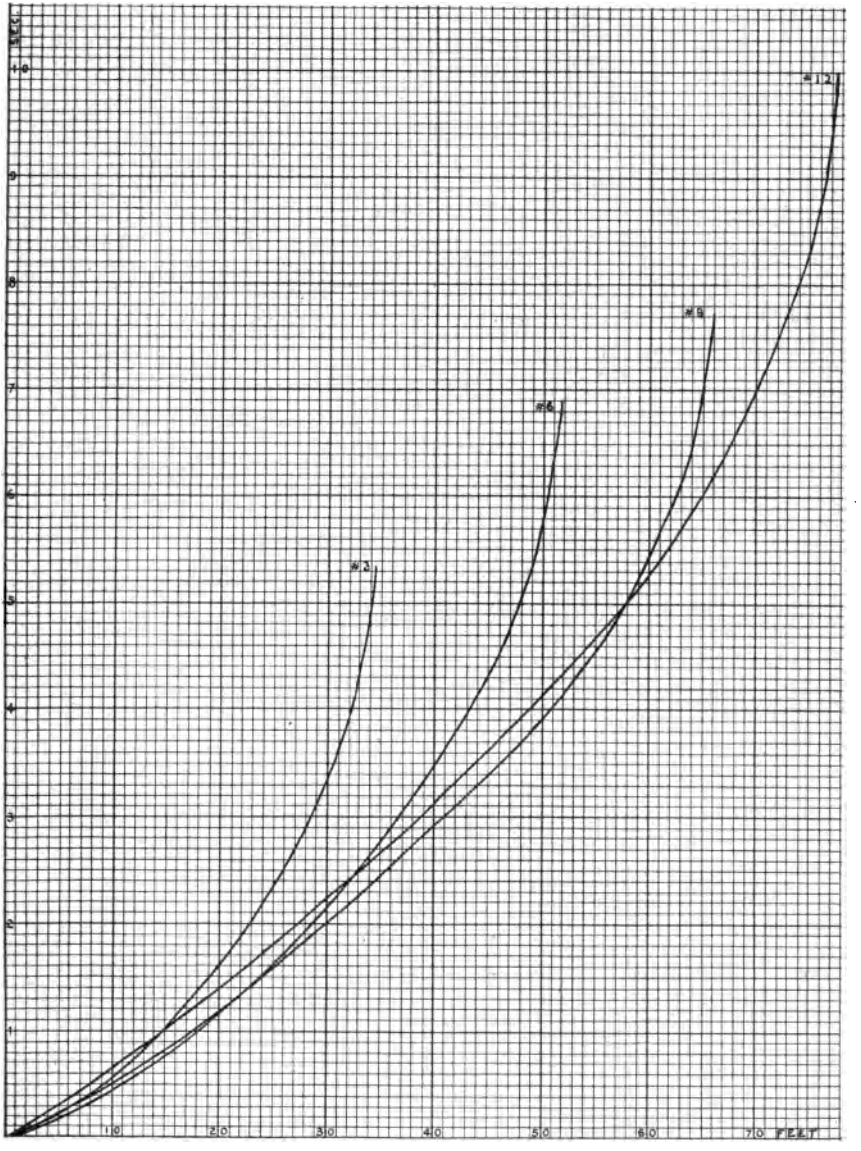

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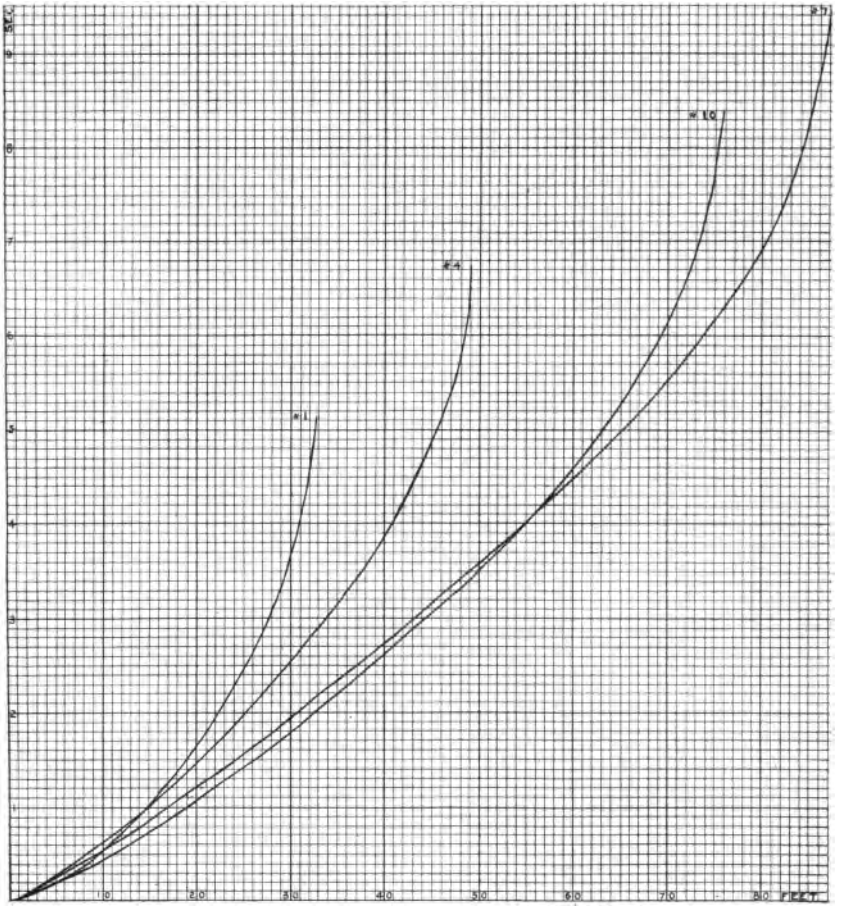

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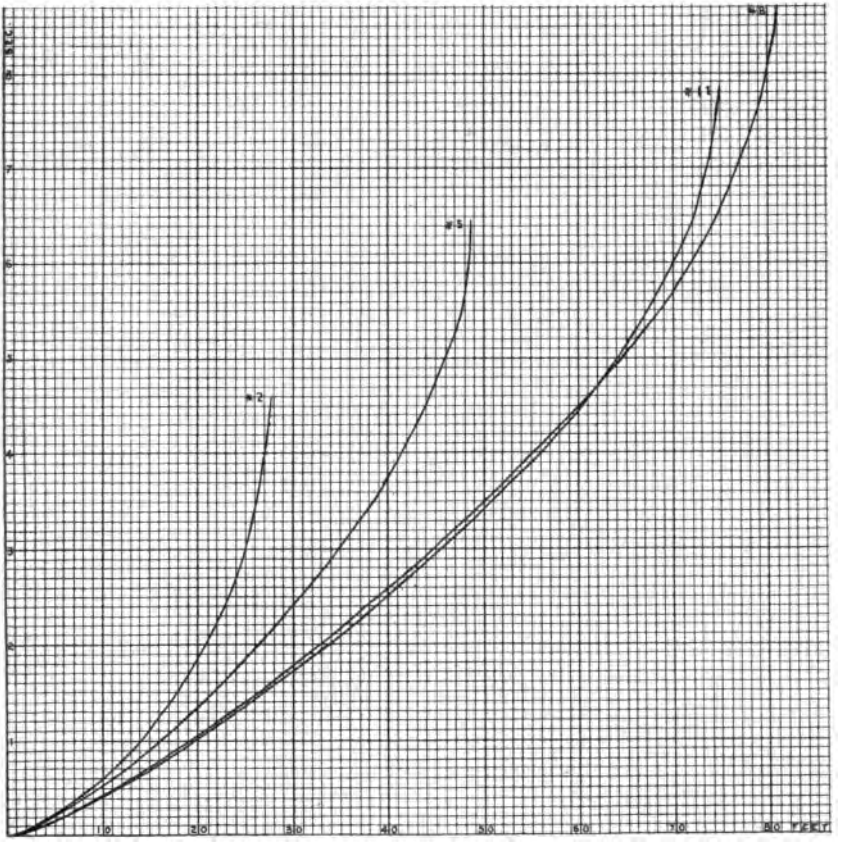

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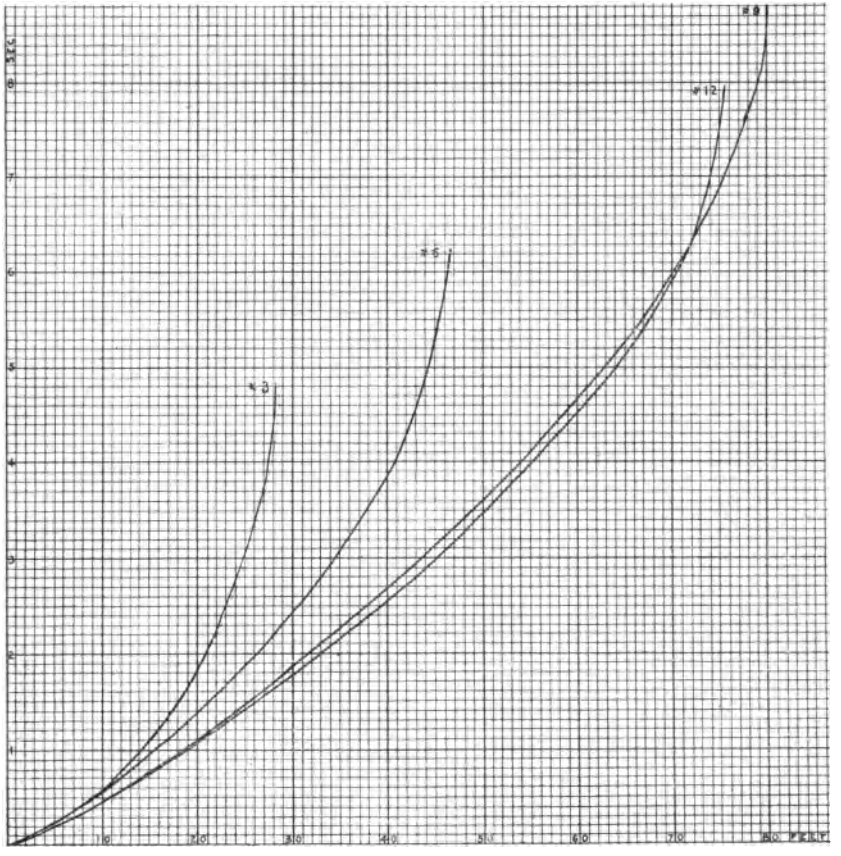

Cross-section Sheet No. 67.

The following tables, numbered from 1 to 15, are tabulated from the curves shown on the preceding diagrams. On each table are full explanatory notes:

TABLE No. 1.

Showing result of curves and other information in reference to test of air brakes, submitted by J. E. Reyburn, tested October 17, 1899 — Car No 1453.

Cross section, sheet number.	Curve number on cross section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
34	1	1	8	68	3	7.30	Down.	21	.....	.....	Did not skid.
35	2	2	8	67	.....	7.30	Down.	21	.....	.....	Did not skid.
36	3	3	8	65	2	6.90	Down.	21	66.80	7.17	Skid 1 rear large wheel, 6 feet.
34	4	4	12	95	.....	9.00	Down.	21	.....	.....	Skid 1 rear large wheel, 6 feet.
35	5	5	12	90	.....	8.50	Down.	21	.....	.....	Skid 1 rear large wheel, 6 feet.
36	6	6	12	97	.....	8.15	Down.	21	94.00	8.55	Skid 1 rear large wheel, 6 feet.

Weather clear, rail dry. Test could not be completed, as car could not make 15 miles per hour.

TABLE No. 2.

Showing result of curves and other information in reference to test of electric brake submitted by the Electric Selector and Signal Company, tested November 27, 1899 — Car No. 1450.

Cross section, sheet number.	Curve number on cross section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
45	1	1	8	37	10	6.06	Down.	11	.....	.....	Did not skid.
46	2	2	8	38	5	6.25	Down.	11	.....	.....	Did not skid.
47	3	3	8	40	6	6.85	Down.	11	38.75	7.71	Did not skid.
45	4	4	12	48	.....	8.15	Down.	11	.....	.....	Skid 2 rear wheels, 5 feet.
46	5	5	12	50	6	7.70	Down.	11	.....	.....	Skid 1 rear large wheel, 5 feet.
47	6	6	12	51	.....	8.00	Down.	11	50.00	7.95	Skid 1 rear large wheel, 8 feet.
45	7	7	15	60	7	8.07	Down.	11	.....	.....	Did not skid.
46	8	8	15	59	.....	8.25	Down.	11	.....	.....	Skid 1 rear large wheel, 10 feet.
47	9	9	15	60	6	8.54	Down.	11	60.02	8.28	Skid 1 rear large wheel, 10 feet.
45	10	10	16	65	.....	9.00	Up.	11	.....	.....	Skid 1 rear large wheel, 15 feet.
46	11	11	16	67	6	8.80	Up.	11	.....	.....	Sdid 1 rear large wheel, 15 feet.
47	12	12	16	84	6	10.25	Up.	11	72.33	9.35	Skid 1 rear large wheel, 20 feet.
48	13	13	16	70	6	8.95	Up.	11	.....	.....	With sand. Skid 1 rear large wheel, 30 feet.
48	14	14	16	75	8	8.90	Up.	11	73.08	8.92	With sand. Skid 1 rear large wheel, 30 feet.

Sun shining; track dry.

TABLE No. 3.

Showing result of curves and other information in reference to test of hand power brake submitted by the Sterling Supply and Manufacturing Company, tested November 22, 1899 — Car No. 1661.

Cross section, sheet number.	Curve number on cross section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
55	1	1	8	47	.....	7.70	Down.	16	.....	.....	Skid 1 large rear wheel, 6 feet.
56	2	2	8	38	8	6.42	Down.	16	.....	.....	Skid 1 large rear wheel, 5 feet.
57	3	3	8	38	10	6.85	Down.	16	41.50	6.99	Skid 1 large rear wheel, 5 feet.
55	4	4	12	55	6	7.75	Down.	16	.....	.....	Skid 1 large rear wheel, 8 feet.
56	5	5	12	58	6	8.05	Down.	16	.....	.....	Skid 1 large rear wheel, 6 feet.
57	6	6	12	57	.....	7.95	Down.	16	57.00	7.91	Skid 1 large rear wheel, 5 feet.
55	7	7	15	79	6	10.37	Down.	16	.....	.....	Skid 1 large rear wheel, 5 feet.
56	8	8	15	73	.....	9.85	Down.	16	.....	.....	Did not skid.
57	9	9	15	73	4	8.55	Down.	16	75.27	9.59	Did not skid.
55	10	10	16	82	4	9.35	Up.	16	.....	.....	Skid 1 large rear wheel, 6 feet.
56	11	11	16	84	5	9.10	Up.	16	.....	.....	Did not skid.
57	12	12	16	77	6	9.60	Up.	16	81.41	9.35	Skid 1 large rear wheel, 6 feet.
58	13	13	16	83	4	8.75	Up.	16	.....	.....	Sand. Skid 1 large rear wheel, 8 feet.
58	14	14	16	98	.....	10.15	Up.	16	90.66	9.45	Sand. Skid 1 large rear wheel, 25 feet.

Weather cloudy; rail dry.

TABLE No. 4.

Showing result of curves and other information in reference to test of electric brake submitted by Price, Darling & Company, tested November 23, 1899 — Car No. 1451.

Cross section, sheet number.	Curve number on cross section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
54	1	1	8	37	10	7.15	Down.	12	.....	.....	Skid 1 large rear wheel, 6 feet.
54	2	2	8	44	.....	7.40	Down.	12	.....	.....	Skid 1 large rear wheel, 8 feet.
54	3	3	8	54	.... .	7.15	Down.	12	45.27	7.23	Skid 1 large rear wheel, 5 feet.

No tests were made after the 8 miles per hour, owing to the failure of the brake. A coil burned out, disabling the system.

TABLE No. 5.

Showing the result of curves and other information in reference to test of air brake submitted by the G. P. Magann Air Brake Company, tested November 22, 1899 — Car No. 1459.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
50	1	1	8	47	.....	6.32	Down.	16	.....	.....	Skid all wheels, 18 feet.
51	2	2	8	40	.....	6.75	Down.	16	.....	.....	Skid 2 large wheels, 15 feet.
52	3	3	8	41	2	7.20	Down.	16	42.72	6.75	Skid 2 large wheels, 10 feet.
50	4	4	12	51	3	6.50	Down.	16	.....	.....	Skid 2 large wheels, 10 feet.
51	5	5	12	61	2	8.30	Down.	16	.....	.....	Skid 2 large wheels, 10 feet.
52	6	6	12	58	.....	7.20	Down.	16	56.80	7.33	Skid 1 rear large wheel, 6 feet.
50	7	7	15	85	6	9.67	Down.	16	.....	.....	Skid all wheels, 12 feet.
51	8	8	15	78	6	8.35	Down.	16	.....	.....	Skid 1 large rear wheel, 5 feet.
52	9	9	15	81	5	9.35	Up.	16	81.80	9.12	Skid all wheels, 10 feet.
50	10	10	16	87	.....	7.85	Up.	16	.....	.....	Skid 1 large rear wheel, 5 feet.
51	11	11	16	97	6	9.40	Up.	16	.....	.....	Did not skid.
52	12	12	16	102	6	10.28	Up.	16	95.66	9.17	Did not skid.
53	13	13	16	92	8	9.15	Up.	16	.....	.....	Sand. Did not skid.
53	14	14	16	85	8	8.25	Up.	16	89.16	8.70	Sand. Skid 1 large rear wheel, 6 feet.

Weather cloudy, track dry.

TABLE No. 6.

Showing result of curves and other information in reference to test of hand brake submitted by M. H. Vogel, tested November 22, 1899 — Car No. 1489.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
38	1	1	8	50	.....	7.85	Down.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
39	2	2	8	53	.....	7.48	Down.	12	.....	.....	Skid 1 large rear wheel, 6 feet.
40	3	3	8	49	7	7.35	Down.	12	50.86	7.56	Skid 1 large rear wheel, 6 feet.
38	4	4	12	79	.....	8.20	Down.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
39	5	5	12	66	.....	7.10	Down.	12	.....	.....	Skid 1 large rear wheel, 8 feet.
40	6	6	12	73	6	8.30	Down.	12	72.83	7.86	Skid 1 large rear wheel, 5 feet.
38	7	7	15	96	6	9.70	Down.	12	.....	.....	Skid 1 large rear wheel, 6 feet.
39	8	8	15	92	10	9.90	Down.	12	.....	.....	Skid 1 large rear wheel, 8 feet.
40	9	9	15	87	.....	9.25	Down.	12	92.11	9.62	Skid 1 large rear wheel, 5 feet.
38	10	10	16	116	.....	9.60	Up.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
39	11	11	16	114	6	9.80	Up.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
40	12	12	16	129	4	12.30	Up.	12	119.94	10.56	Skid 1 large rear wheel, 6 feet.
41	13	13	16	108	8	9.35	Up.	12	.....	.....	Sand. Skid 1 large rear wheel, 8 feet.
41	14	14	16	104	6	9.35	Up.	12	106.58	9.35	Sand. Skid 1 large rear wheel, 8 feet.

Weather cloudy, track dry.

TABLE No. 7.

Showing result of curves and other information in reference to test of equalizing system of leverages used with the Sterling brake submitted by the Safety Appliance Company, tested November 10, 1899 -- Car No. 1480.

Cross-section sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
42	1	1	8	39	8	3.20	Down.	13	.....	.....	Skid 2 large wheels, 6 feet.
43	2	2	8	41	.....	3.22	Down.	13	.....	.....	Did not skid.
44	3	3	8	40	2	3.02	Down.	13	40.27	3.15	Skid 2 large wheels, 5 feet.
42	4	4	12	68	.....	4.62	Down.	13	.....	....	Skid 2 large wheels, 6 feet.
43	5	5	12	72	8	5.05	Down.	13	.....	.....	Skid 2 large wheels, 8 feet.
44	6	6	12	64	10	3.95	Down.	13	68.36	4.54	Skid 2 large wheels, 5 feet.
42	7	7	15	133	6	5.90	Up.	13	.....	.....	Skid 1 large rear wheel, 6 feet.
43	8	8	15	131	6	5.90	Up.	13	.....	.....	Skid 1 large rear wheel, 5 feet.
44	9	9	15	140	4	5.95	Up.	13	135.11	5.92	Skid 1 large rear wheel, 6 feet.
42	10	10	16	137	.....	6.80	Up.	13	.....	.....	Skid 1 large rear wheel, 8 feet.
43	11	11	16	142	3	5.90	Up.	13	.....	.....	Skid 1 large rear wheel, 8 feet.
44	12	12	16	142	10	6.02	Up.	13	140.69	6.07	Skid 1 large rear wheel, 10 feet.

No test made with sand. Weather clear, track dry.

TABLE No. 8.

Showing result of curves and other information in reference to test of friction brake submitted by J. G. Brill & Company, tested October 17, 1899 — Car No. 1451.

Cross-section sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
29	1	1	8	38	11	3.30	Down.	17	.....	.....	Skid 1 rear large wheel, 5 feet.
30	2	2	8	31	10	2.90	Down.	17	.....	.....	Skid 1 rear large wheel, 5 feet.
31	3	3	8	34	7	3.27	Down.	17	35.11	3.16	Skid 1 rear and 1 front wheel, 8 feet.
29	4	4	12	69	9	7.40	Down.	17	.....	.....	Skid all wheels, 10 feet.
30	5	5	12	64	.....	5.10	Down.	17	.....	.....	Skid 1 large rear wheel, 6 feet.
31	6	6	12	69	9	5.85	Down.	17	67.83	5.95	Skid 2 rear wheels, 5 feet.
29	7	7	15	113	5	7.45	Down.	17	.....	.....	Skid all wheels, 8 feet.
30	8	10	15	139	6	8.75	Up.	17	.....	.....	Did not skid.
31	9	11	15	113	9	6.30	Up.	17	121.88	7.50	Skid all wheels, 6 feet.
29	10	8	16	112	9	6.35	Down.	24	.....	.....	Skid 1 large rear wheel, 5 feet.
30	11	9	16	101	11	6.45	Down.	24	.....	.....	Skid all wheels, 8 feet.
31	12	12	16	110	8	5.85	Up.	24	108.44	6.22	Skid all wheels, 10 feet.
32	13	13	16	149	5	8.45	Up.	24	.....	.....	Sand. Skid all wheels, 12 feet.
32	14	14	16	104	11	6.50	Up.	24	127.16	7.47	Sand. Skid 2 rear wheels, 8 feet.

Weather clear, rail dry.

TABLE No. 9.

Showing result of curves and other information in reference to test of Wedge brake submitted by the Sauvage Brake Company, tested October 17, 1899 — Car No. 1452.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
25	1	1	8	49	6	4.65	Down.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
26	2	15	8	42	4	3.25	Up.	12	.....	.....	Did not skid.
27	3	16	8	46	6	4.10	Up.	12	46.11	4.00	Skid 1 large rear wheel, 5 feet.
25	4	17	12	79	7	5.75	Up.	12	.....	.....	Did not skid.
26	5	6	12	83	9	6.31	Down.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
27	6	7	12	72	5	4.95	Down.	12	78.58	5.67	Skid 1 large rear wheel, 5 feet.
25	7	4	15	137	9	9.55	Up.	12	.....	.....	Skid 1 large rear wheel, 8 feet.
26	8	8	15	125	9	8.35	Up.	12	.....	.....	Skid 1 large rear wheel, 6 feet.
27	9	9	15	124	.....	7.60	Up.	12	129.16	8.50	Skid 1 large rear wheel, 5 feet.
25	10	10	16	147	1	9.74	Up.	12	.....	.....	Skid 1 large rear wheel, 5 feet.
26	11	11	16	135	9	8.45	Up.	12	.....	.....	Skid 1 large rear wheel, 10 feet.
27	12	12	16	132	.....	7.60	Up.	12	138.27	8.60	Skid 1 large rear wheel, 5 feet.
28	13	13	16	144	6	7.70	Up.	12	.....	.....	Sand. Did not skid.
28	14	14	16	142	.....	6.93	Up.	12	143.25	7.31	Sand. Did not skid.

Weather cloudy, track fair.

TABLE No. 10.

Showing result of curves and other information in reference to test of electric brake submitted by the Columbia Car Light and Brake Company, tested October 17, 1899 — Car No. 1459.

Cross-section sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
21	1	1	8	72	.....	6.60	Down.	11	.....	.....	Did not skid.
22	2	2	8	64	11	6.20	Down.	11	.....	.....	Did not skid.
23	3	3	8	60	8	5.70	Down.	11	65.86	6.16	Did not skid.
21	4	4	12	89	6	5.20	Down.	11	.....	.....	Did not skid.
22	5	5	12	95	7	5.50	Down.	11	.....	.....	Did not skid.
23	6	6	12	114	9	5.70	Down.	11	99.94	5.46	Did not skid.
21	7	7	15	139	6	7.10	Up.	11	.....	.....	Did not skid.
22	8	8	15	138	11	7.00	Up.	11	.....	.....	Did not skid.
23	9	9	15	140	1	7.80	Up.	11	139.50	7.30	Did not skid.
21	10	10	16	148	3	7.90	Up.	11	.....	.....	Did not skid.
22	11	11	16	156	4	7.60	Up.	11	.....	....	Skid 2 rear wheels, 5 feet.
23	12	12	16	160	8	7.60	Up.	11	155.08	7.70	Did not skid.
24	13	13	16	196	5	7.20	Up.	11	.....	.....	Sand. Did not skid.
24	14	14	16	210	11	7.90	Up.	11	203.66	7.55	Sand. Skid 2 rear wheels, 6 feet.

Weather cloudy, track fair.

TABLE No. 11.

Showing result of curves and other information in reference to test of air brake submitted by the Standard Air Brake Company, tested August 31, 1899 — Car No. 1464.

Cross section, sheet number.	Curve number on cross section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
9	1	6	8	57	1	5.83	Down.	21	.. ...	.. ...	Skid all wheels, 25 feet.
10	2	7	8	52	10	5.86	Down.	21	.....	.....	Skid all wheels, 15 feet.
11	3	8	8	52	8	5.68	Down.	21	54.19	5.79	Skid all wheels 20 feet.
9	4	1	12	73	5	6.30	Down.	21	.....	.....	Skid 1 large rear wheel, 20 feet.
10	5	2	12	65	6	5.53	Down.	21	.....	.....	Skid 1 large rear wheel, 15 feet.
11	6	3	12	89	4	4.60	Down.	21	76.08	5.48	Did not skid.
9	7	1	15	89	10	8.53	Down.	21	.....	.....	Did not skid.
10	8	2	15	84	.....	6.55	Down.	21	.....	.....	Skid 1 rear large wheel, 5 feet.
11	9	3	15	86	8	6.88	Down.	21	86.83	7.32	Skid 1 rear large wheel, 5 feet.
9	10	4	16	117	6	9.87	Up.	21	.....	.....	Skid all wheels, 10 feet.
10	11	6	16	100	.....	7.80	Up.	21	....	.....	Skid 1 large rear wheel, 6 feet.
11	12	7	16	95	11	7.78	Up.	21	104.47	8.48	Skid 1 large rear wheel. 6 feet.
12	13	9	16	93	1	6.66	Up.	21	.....	.....	Sand. Skid all wheels, 8 feet.
12	14	10	16	93	....	6.50	Up.	21	93.04	6.58	Sand. Skid all wheels, 12 feet.

Weather cloudy; track fair.

TABLE No. 12.

Showing result of curves and other information in reference to test of electric brake submitted by the General Electric Company, tested August 29, 1899 — Car No. 2255.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
17	1	9	8	52	7	6.15	Down.	24	.....	.....	Did not skid.
18	2	8	8	46	1	5.47	Down.	24	.....	.....	Did not skid.
19	3	10	8	36	4	4.40	Down.	24	45.00	5.34	Did not skid.
17	4	5	12	110	4	9.00	Down.	24	.....	.....	Did not skid.
18	5	7	12	117	8	9.51	Down.	24	.....	.....	Did not skid.
19	6	6	12	105	1	8.33	Down.	24	111.02	8.95	Did not skid.
17	7	2	15	113	11	7.76	Down.	24	.....	.....	Did not skid.
18	8	1	15	110	4	8.25	Down.	24	.....	.....	Did not skid.
19	9	3	15	120	4	8.96	Down.	24	114.86	8.32	Did not skid.
17	10	11	16	128	5	8.47	Up.	24	.....	.....	Did not skid.
18	11	12	16	138	7	8.50	Up.	24	.....	.....	Did not skid.
19	12	13	16	137	2	8.88	Up.	24	134.72	8.62	Did not skid.
20	13	14	16	113	7	6.41	Up.	24	.....	.....	Sand. Did not skid.
20	14	15	16	119	9	6.75	Up.	24	116.66	6.58	Sand. Skid 2 rear wheels, 10 feet

Wheels slipped on track but continued to revolve. This would not flatten them. Weather clear, track dry.

TABLE No. 13.

Showing result of curves and other information in reference to test of Price friction brake submitted by the Peckham Motor, Truck and Wheel Company, tested August 30, 1899 — Car No. ——.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
1	1	9	8	31	4	3.72	Down.	24	.....	.....	Skid 2 rear wheels, 15 feet.
2	2	8	8	62	2	15.11	Down.	24	.....	.....	Skid 2 rear wheels, 20 feet.
3	3	10	8	33	9	4.25	Down.	24	42.41	7.03	Skid 2 rear wheels, 15 feet.
1	4	5	12	63	11	7.01	Down.	24	.....	.... .	Skid all wheels, 25 feet.
2	5	7	12	63	9	6.76	Down.	25	.....	.....	Skid all wheels, 20 feet.
3	6	6	12	50	11	5.56	Down.	25	59.52	6.44	Skid 2 rear wheels, 15 feet.
1	7	2	15	69	6	7.65	Down	25	.....	.....	Skid all wheels, 15 feet.
2	8	1	15	63	10	5.20	Down.	30	.....	.....	Skid all wheels, 20 feet.
3	9	3	15	78	2	7.77	Down.	30	70.50	6.87	Skid 2 rear wheels, 15 feet.
-	10	11	16	80	3	8.20	Up.	30	.....	.....	Skid 2 rear wheels, 15 feet.
2	11	12	16	84	10	7.20	Up.	30	.....	.....	Skid all wheels, 20 feet.
3	12	13	16	78	8	6.90	Up.	30	81.25	7.43	Skid all wheels, 20 feet.
4	13	15	16	91	8	8.35	Up.	30	.....	.. ...	Sand. Skid all wheels, 25 feet.
4	14	14	16	68	2	6.67	Up.	30	79.91	7.51	Sand. Skid all wheels, 25 feet.

Weather clear, track dry.

TABLE No. 14.

Showing result of curves and other information in reference to test of track and wheel brake submitted by the Devlin Street Car Brake Company, tested August 30, 1899 — Car No. 1452.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
5	1	8	8	61	3	7.00	Down.	27	.....	.....	Skid all wheels, 10 feet.
6	2	10	8	56	10	8.55	Down.	27	.....	.....	Skid all wheels, 8 feet.
7	3	11	8	44	2	6.58	Down.	27	54.08	7.38	Skid all wheels, 6 feet.
5	4	5	12	76	2	12.87	Down.	27	.....	.....	Skid 2 front wheels, 5 feet.
6	5	6	12	60	10	6.83	Down.	27	.....	.....	Skid all wheels, 6 feet.
7	6	7	12	60	5	7.39	Down.	27	65.80	8.86	Skid all wheels, 6 feet.
5	7	1	15	105	10	10.27	Down.	21	.....	.....	Skid 2 front wheels, 8 feet.
6	8	2	15	90	10	9.06	Down.	21	.....	.....	Skid 2 front wheels, 6 feet.
7	9	4	15	80	5	9.42	Down.	21	92.36	9.58	Skid all wheels, 5 feet.
5	10	12	16	96	8	9.59	Up.	27	.....	.....	Skid all wheels, 5 feet.
6	11	13	16	95	10	9.44	Up.	27	.....	.....	Skid all wheels, 8 feet.
7	12	14	16	88	5	9.50	Down.	27	93.63	9.51	Skid 2 front wheels, 6 feet.
8	13	15	16	77	6	8.03	Down.	27	.....	.....	Sand. Skid all wheels, 10 feet.
8	14	16	16	92	4	7.92	Down.	27	84.91	7.98	Sand. Skid all wheels, 12 feet.

Weather clear, track dry.

TABLE No. 15.

Showing result of curves and other information in reference to test of air brake submitted by the Christe sen Engineering Company, tested August 31, 1899 — Car No. 1450.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
13	1	4	8	61	2	6.70	Down.	27	.....	.....	Did not skid.
14	2	5	8	53	4	5.83	Down.	27	.....	.....	Did not skid.
15	3	6	8	56	1	6.08	Down.	27	56.86	6.20	Did not skid.
13	4	1	12	88	2	7.70	Down.	27	.....	.....	Did not skid.
14	5	2	12	91	.....	8.15	Down.	27	.....	.....	Did not skid.
15	6	3	12	85	7	7.80	Down.	27	88.25	7.88	Did not skid.
13	7	7	15	112	11	8.65	Down.	27	.....	.....	Did not skid.
14	8	8	15	107	8	8.16	Down.	27	.....	.....	Did not skid.
15	9	9	15	120	10	8.98	Down.	27	113.80	8.60	Did not skid.
13	10	10	16	154	1	10.66	Up.	27	.....	.....	Skid all wheels, 20 feet.
14	11	11	16	132	8	10.20	Up.	27	....	.....	Did not skid.
15	12	1	16	105	6	8.37	Up.	27	130.75	9.74	Did not skid.
16	13	3	16	92	7	7.00	Up.	27	.....	.....	Sand. Skid all wheels, 5 feet.
16	14	2	16	94	10	6.25	Up.	27	93.70	6.68	Sand. Skid all wheels, 6 feet.

Table No. 16 is a recapitulation of the foregoing tables, and shows average stop in feet and seconds, at different speeds.

TABLE No. 16.

Showing average stops made with all brakes tested at 8, 12, 15 *and* 16 *miles per hour, and at* 16 *miles per hour with sand.*

NAME OF BRAKE.	8 MILES PER HOUR.		12 MILES PER HOUR.		15 MILES PER HOUR.		16 MILES PER HOUR.		16 MILES PER HOUR, WITH SAND.	
	Feet.	Seconds.	Feet.	Seconds.	Feet.	Seconds.	Feet.	Seconds.	Feet.	Seconds.
Peckham Motor, Truck and Wheel Company	42.41	7.03	59.52	6.44	70.50	6.87	81.25	7.43	79.91	7.51
Devlin Street Car Brake Company	54.08	7.38	65.80	8.86	92.36	9.58	93.63	9.51	84.91	7.98
Christensen Air Brake Company	56.86	6.20	88.25	7.88	113.80	8.60	130.75	9 74	93.70	6.63
Standard Air Brake Company	54.19	5.79	76.08	5.48	86.83	7.33	104.47	8.48	93.04	6.58
General Electric Company	45.00	5.84	111.02	8.95	114.86	8 32	134.72	8.62	116.66	6 58
Columbia Car Light and Brake Company	65.86	6.16	99.94	5.46	139.50	7.30	155.08	7.70	203.66	7.55
Sauvage Street Car Brake Company	46.11	4.00	78.58	5.67	129.16	8.50	138.27	8.60	143.25	7.31
J. G. Brill Company	35.11	3.16	67.83	6.12	121.88	7.50	106.44	6.22	127.16	7.47
Safety Appliance Company	40.27	3.15	68.36	4.54	135.11	5.92	140.69	6.07	†	†
Vogel Brake Company	50.86	7.56	72.83	7.86	92.11	9.62	119.94	10.56	106.58	9.35
G. P. Magann Air Brake Company	42.72	6.75	56.80	7.33	81.80	9.12	95.66	9.17	89.16	8.70
Price-Darling Company*	45.27	7.23	.....	.....	.....	.....	.....	.....	.....	.....
Sterling Supply & Manufacturing Company	41.50	6.99	57.00	7.91	75.27	9.59	81.41	9.35	90.66	9.45
Electric Selector and Signal Company	38.75	7.71	50.00	7.95	60.02	8.28	72.33	9.35	73.08	8.92
Bach & Schlegel †	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
J. E. Reyburn‡	66.80	7.17	94.00	8.55	.....	.....	.....	.....	.....	.....

* No tests after 8 miles per hour. † No test. ‡ No tests after 12 miles per hour.

Tables numbered 17 to 21 show comparative average stop made by each brake and at the different rates of speed:

TABLE No. 17.

Showing comparative stops at 8 miles per hour.

NAME OF COMPANY.	Feet.	Seconds.
J. G. Brill Company	35.11	3.16
Electric Selector and Signal Company	38.75	6.39
Safety Appliance Company	40.27	3.15
Sterling Supply and Manufacturing Company,	41.50	6.99
Peckham Motor, Truck and Wheel Company	42.41	7.03
G. P. Magann Air Brake Company	42.72	6.75
General Electric Company	45.00	5.34
Price-Darling Co.	45.27	7.23
Sauvage Street Car Brake Company	46.11	4.00
Vogel Brake Company	50.86	7.56
Devlin Street Car Brake Company	54.08	7.38
Standard Air Brake Company	54.19	5.79
Christensen Air Brake Company	56.86	6.20
Columbia Car Light and Brake Company	65.86	6.16
J. E. Reyburn	66.80	7.17

TABLE No. 18.

Showing comparative stops at 12 miles per hour.

NAME OF COMPANY.	Feet.	Seconds.
Electric Selector and Signal Company	50.00	7.95
G. P. Magann Air Brake Company	56.80	7.33
Sterling Supply Company	57.00	7.91
Peckham Motor, Truck and Wheel Company	59.52	6.44
Devlin Street Car Brake Company	65.80	8.86
J. G. Brill Company	67.83	6.12
Safety Appliance Company	68.36	4.54
Vogel Brake Company	72.83	7.86
Standard Air Brake Company	76.08	5.48
Sauvage Street Car Brake Company	78.58	5.67
Christensen Air Brake Company	88.25	7.88
J. E. Reyburn	94.00	8.55
Columbia Car, Light and Brake Company	99.94	5.46
General Electric Company	111.02	8.95

TABLE No. 19.

Showing comparative stops at 15 *miles per hour.*

NAME OF COMPANY.	Feet.	Seconds.
Electric Selector and Signal Company.....	60.02	8.28
Peckham Motor, Truck and Wheel Company..	70.50	6.87
Sterling Supply Company	75.27	9.59
G. P. Magann Air Brake Company.....	81.80	9.12
Standard Air Brake Company.....	86.83	7.32
Vogel Brake Company	92.11	9.62
Devlin Street Car Brake Company.....	92.36	9.58
Christensen Air Brake Company	113.80	8.60
General Electric Company	114.86	8.32
J. G. Brill Company.....	121.88	7.50
Sauvage Street Car Brake Company.....	129.16	8.50
Safety Appliance Company	135.11	5.92
Columbia Car, Light and Brake Company....	139.50	7.30

TABLE No. 20.

Showing comparative stops at 16 *miles per hour.*

NAME OF COMPANY.	Feet	Seconds.
Electric Selector and Signal Company.....	72.33	9.35
Peckham Motor, Truck and Wheel Company..	81.25	7.43
Sterling Supply and Manufacturing Company,	81.41	9.35
Devlin Street Car Brake Company.....	93.63	9.51
G. P. Magann Air Brake Company.....	95.66	9.17
Standard Air Brake Company	104.47	8.48
J. G. Brill Company	108.44	6.22
Vogel Brake Company	119.94	10.56
Christensen Air Brake Company.....	130.75	9.74
General Electric Company	134.72	8.62
Sauvage Street Car Brake Company.....	138.27	8.60
Safety Appliance Company	140.69	6.07
Columbia Car, Light and Brake Company.....	155.08	7.70

TABLE No. 21.

Showing comparative stops at 16 miles per hour, with sand.

NAME OF COMPANY.	Average stops. Feet.	Seconds.
Electric Selector and Signal Company.....	73.08	8.92
Peckham Motor, Truck and Wheel Company..	79.91	7.51
Devlin Street Car Brake Company.....	84.91	7.98
G. P. Magann Air Brake Company.....	89.16	8.70
Sterling Supply and Manufacturing Company,	90.66	9.45
Standard Air Brake Company	93.04	6.58
Christensen Air Brake Company	93.70	6.63
Vogel Brake Company	106.58	9.35
General Electric Company	116.66	6.58
J. G. Brill Company.....	127.16	7.47
Sauvage Street Car Brake Company.....	143.25	7.31
Columbia Car, Light and Brake Company....	203.66	7.55

Table No. 22 shows the comparative average stop made with all brakes and at all speeds.

TABLE No. 22.

Showing comparative average stops at all speeds.

NAME OF COMPANY.	Feet.
Electric Selector and Signal Company.....	58.83
Peckham Motor, Truck and Wheel Company.....	66.71
Sterling Supply and Manufacturing Company.....	69.16
G. P. Magann Air Brake Company.....	73.22
Devlin Street Car Brake Company.....	78.15
Standard Air Brake Company	82.92
Vogel Brake Company	88.46
J. G. Brill Brake Company.....	92.08
Christensen Air Brake Company.....	96.67
General Electric Company	104.45
Sauvage Brake Company	107.07
Columbia Car, Light and Brake Company.....	132.80
J. E. Reyburn*	.....
Price-Darling Brake*	.....
Safety Appliance Brake*	.....
Bach & Schlegel*	.....

* Not tested on all speeds.

Table No. 23 shows the percentage of standing of each brake, computed on the formula* $\frac{w\,s^2}{d}$ equals percentage of efficiency. Also, percentage deducted from this standing for skidding of wheels.

TABLE No. 23.

Showing standing of brakes based on the formula and per cent. of rating based on the average stops, also per cent. deducted from this standing for skidding of wheels and the per cent. of rating after making this deduction.

NAME OF COMPANY.	Formula $\frac{w\,s^2}{d}$	Average stop at all speeds, feet.	Per cent of rating based on average stop.	Per cent. deducted for skidding of wheels.	Per cent. of rating after deduction.
Electric Selector and Signal Co...	66,197	58.88	100.00	1.7875	98.26
Sterling Supply and Manufacturing Company.....	58,078	69.16	87.73	.875	86.86
Peckham Motor, Truck and Wheel Company.....	64,410	66.71	97.80	10.70	96.60
G. P. Magann Air Brake Company	54,853	78.22	82.86	4.00	78.86
Devlin Street Car Brake Company	54,424	78.15	82.21	6.20	76.01
Standard Air Brake Company....	49,907	82.92	75.39	5.75	69.64
General Electric Company.....	45,630	104.45	68.93	.225	68.71
Vogel Brake Company.....	44,300	88.46	66.92	.875	66.05
Christensen Air Brake Company..	44,322	96.67	66.95	2.00	64.95
J. G. Brill Brake Company.....	44,545	92.08	67.29	4.35	62.94
Safety Appliance Company†.....	38,290	96.10	57.84	1.0625	56.78
Sauvage Brake Company.....	36,600	107 07	55.29	.6875	54.60
Price, Darling & Company‡	31,803	45.27	48.04	.1875	47.85
J. G. Reyburn Brake§.....	29,547	80.40	44.63	.25	44.38
Columbia Car, Light and Brake Company.....	29,325	132.80	44.30	.225	44.08
Bach & Schlegel (no test).....	.....	.....	.....	.....	.....

Per cent. deducted for skidding wheels is based on the following values:

Skidding 15 feet or more.		Skidding 10 feet to 15 feet.		Skidding 5 feet to 10 feet.	
One large wheel.....	.25	One large wheel.....	.125	One large wheel.....	.0625
One small wheel	.125	One small wheel.	.0625	One small wheel .	.05125
Large and small wheels	.45	Large and small wheels	.225	Large and small wheels	.1125
All wheels.....	1.00	All wheels.....	.75	Al wheels....	.50

*w = Number of passengers × 140 + weight of car 20,916 pounds, except the General Electric car, which weighed 24,000 pounds.
s2 = The average initial speed squared.
d = The average stop at all speeds.

† Tested at 8 miles only.
‡ Tested at 8 and 12 miles only.
§ Tested at 8, 12 and 15 miles only.

Table No. 24 shows the standing of the different brakes after deducting percentage for skidding of wheels.

TABLE No. 24.

Showing per cent. "standing of brakes" after deducting per cent. for skidding of wheels.

NAME OF COMPANY.	Per cent. standing.
Electric Selector and Signal Company	98.26
Sterling Supply and Manufacturing Company	86.86
Peckham Motor, Truck and Wheel Company	86.60
G. P. Magann Air Brake Company	78.86
Devlin Street Car Brake Company	76.01
Standard Air Brake Company	69.64
General Electric Company	68.71
Vogel Brake Company	66.05
Christensen Air Brake Company	64.95
J. G. Brill Brake Company	62.94
Safety Appliance Company	56.78
Sauvage Brake Company	54.60
Price, Darling & Co.	47.85
J. G. Reyburn Brake	44.38
Columbia Car Light and Brake Company	44.08
Bach & Schlegel	.....

EXPERIMENTAL TESTS IN ADDITION TO THE REGULAR TEST.

Table No. 25 shows the test of a car equipped with the ordinary spindle hand brake.

TABLE No. 25.

Showing result of curves and other information in reference to test of car equipped with single chain spindle brake, same brake leverage as used on test of Sterling brake, car equipped with ordinary brake handle, 14-inch sweep, tested November 23, 1899 — Car No. 1661.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.	
59	1	1	8	44	6	6.45	Down.	12	.....	.....	
60	2	2	8	49	.....	6.40	Down.	12	.....	.....	Did not skid.
61	3	3	8	35	6	5.30	Down.	12	43.00	6.05	Did not skid.
59	4	4	12	60	5	7.20	Down.	12	.....	.....	Did not skid.
60	5	5	12	64	.....	7.60	Down.	12	.....	.....	Did not skid.
61	6	6	12	61	5	6.50	Down.	12	61.94	7.10	Did not skid.
59	7	7	15	77	.....	7.85	Down.	12	.....	.....	Did not skid.
60	8	8	15	76	5	7.70	Down.	12	.....	.....	Did not skid.
61	9	9	15	73	4	6.88	Down.	12	75.58	7.47	Did not skid.
59	10	10	16	86	6	8.90	Up.	12	.....	.....	Did not skid.
60	11	11	16	86	8	8.45	Up.	12	.....	.....	Did not skid.
61	12	12	16	89	6	8.70	Up.	12	87.55	8.68	Did not skid.

Sun shining, track dry.

Table No. 26 shows the result of a test of a car equipped with the Sterling brake, with 18 inch wheels, instead of the ordinary brake handle, the table showing the number of pounds of energy exerted on the wheels in bringing the car to a stop, etc.

TABLE No. 26.

Showing result of curves and number of pounds exerted by motorman on brake wheel in test of car equipped with Sterling brake with 18-inch brake wheel in place of brake handle, car tested November 24, 1899.

Cross section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop. Feet.	Stop. Inches.	Stop. Seconds.	Direction of car.	Number of car.	Number of passengers.	Average Stop. Feet.	Average Stop. Seconds.	Number of pounds exerted on brake wheel.	Remarks.
65	1	1	8	32	10	5.15	Down.	.....	12	.....	.....	80	Did not skid.
66	2	2	8	27	7	4.60	Down.	.....	12	.....	.....	80	Did not skid.
67	3	3	8	28	2	4.83	Down.	.....	12	29.52	4.86	75	Did not skid.
65	4	4	12	49	.....	6.75	Down.	.....	12	.....	.....	85	Did not skid.
66	5	5	12	48	6	6.48	Down.	.....	12	.....	.....	65	Did not skid.
67	6	6	12	46	6	6.25	Down.	1661	12	48.00	6.49	70	Did not skid.
65	7	7	15	87	2	9.45	Down.	.....	12	.....	.....	75	Did not skid.
66	8	8	15	81	.....	8.70	Up.	.....	12	.....	.....	80	Did not skid.
67	9	9	15	80	.....	8.80	Up.	.....	12	82.72	8.98	80	Skid rear wheel, 6 feet.
65	10	10	16	75	9	8.40	Up.	.....	12	.....	.....	80	Did not skid.
66	11	11	16	75	.....	7.87	Up.	.....	12	.....	.....	75	Did not skid.
67	12	12	16	75	6	7.95	Up.	.....	12	75.41	8.07	80	Skid rear wheel, 6 feet.

Clear, track dry.

Table No. 27 shows the result of the curves and number of pounds of energy exerted by the motorman on the brake wheel, in test on a car equipped with ordinary spindle brake, with a brake wheel in place of brake handle.

TABLE No. 27.

Showing result of curves and number of pounds exerted by motorman on brake wheel on test of car equipped with spindle brake with 18*-inch brake wheel in place of brake handle, no gears on spindle, tested November* 23, 1899 — *Car No.* 1661.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of passengers.	Average Stop.		Number of pounds exerted by motorman.	Remarks.
				Feet.	Inches.	Seconds.			Feet.	Seconds.		
62	1	1	8	37	.....	6.40	Down.	12	.....	.....	100	Did not skid.
63	2	2	8	39	2	6.40	Down.	12	.....	.....	85	Did not skid.
64	3	3	8	34	5	5.85	Down.	12	36.86	6.05	90	Did not skid.
63	4	4	12	49	6	6.65	Down.	12	.....	.....	85	Skid 1 large rear wheel, 5 feet.
63	5	5	12	51	6	6.47	Down.	12	.....	.....	85	Skid 1 large rear wheel, 3 feet.
64	6	6	12	51	8	6.90	Down.	12	50.88	6.67	100	Skid 1 large rear wheel, 6 feet.
62	7	7	15	62	6	7.40	Down.	12	.....	.....	100	Skid 1 large rear wheel, 6 feet.
63	8	8	15	66	4	7.50	Down.	12	.....	.....	85	Skid 1 large rear wheel, 6 feet.
64	9	9	15	66	.....	7.73	Down.	12	64.94	7.54	90	Skid 1 large rear wheel, 6 feet.
62	10	10	16	74	5	9.70	Up.	12	.....	.....	105	Did not skid.
63	11	11	16	77	6	8.65	Up.	12	.....	.....	90	Did not skid.
64	12	12	16	77	7	10.00	Up.	12	76.50	8.48	95	Skid 1 large rear wheel, 10 feet.

Sun shining, track dry.

Table No. 28 shows the results of curves, and other information in reference to the test of a car equipped with Electric Selector and Signal Company's brake, after the tracks had been wet down by a sprinkling cart.

TABLE No. 28.

Showing result of curves and other information in reference to test of car equipped with Electric Selector and Signal Co. brake; tracks flooded by sprinkling cart, test made December 2, 1899.

Cross-section, sheet number.	Curve number on cross-section sheet.	Curve number on instrument chart.	Initial speed, miles per hour.	Stop.			Direction of car.	Number of car.	Number of passengers.	Average Stop.			Remarks.
				Feet.	Inches.	Seconds.				Feet.	Inches.	Seconds.	
49	1	1	15	77	6	10.08	Up.	....	7	....	....	....	Did not skid.
49	2	2	15	65	6	8.06	Up.	1450	7	....	....	....	Did not skid.
49	3	3	15	71	10	8.95	Up.	....	7	71	61	9.08	Did not skid.

In the formula used for determining the percentage of standing of brakes, $\frac{w}{d}$, the weight of the car in all cases was estimated at 20,816 pounds, except the one used by the General Electric Company, which was a combination car equipped with G. E. 57 motors and weighed 24,000 pounds. The passenger weight was estimated at 140 times the number of persons carried. Notes of the skidding of wheels was made by the electrical expert of the Board, and the number of feet the wheels slipped, though not actually measured, was carefully observed and estimated. The testing apparatus gave perfect satisfaction as to its exactness and efficiency throughout the entire test.

It was found impracticable to conduct the tests in exact accordance with the conditions set forth in the specifications to govern the test. All stops were made as emergency stops. Nearly all contestants labored under the disadvantage of not having an opportunity to properly adjust their respective brakes through the actual service operation of a car, as no facilities or opportunities could be furnished for this purpose except in the run from the shop to the car barn. The General Electric Company labored under the disadvantage of having only two axles equipped with shoes, there being no shoes on the pony wheel axles. Messrs. Bach & Schlegel equipped the car with only four shoes. The construction of their shoe was such, it being a wheel and rail brake, that only the shoes on the forward wheels had any braking effect on the rail. For this reason the car could not be stopped within the limits within which the instrument would record the result. The electric controller of the Price-Darling Company brake burned out after the tests at eight miles per hour were made, so the standing given for this brake is based only upon the test made at that speed. The John E. Reyburn air brake was tested at only eight and twelve miles per hour. This, however, was owing to no defect of the brake. It was found impossible to make the faster speeds with the car equipment; so the standing of this brake is based on stops made at 8 and 12 miles per hour. The Safety Appliance Com-

pany presented a system of leverages for street-car brakes which, during the test, was applied to the Sterling brake.

The standing of the respective brakes, as shown on the foregoing tables, is only the result obtained by the automatic recording instrument, and the record of skidding of wheels as noted.

To this standing must be added or deducted, as the case may be, points for the possession of, or the lack of, the following qualities: Reliability of system, ease of manipulation, simplicity of system, liability of brakes operating when they should not, safety devices in case of disablement of any part of the braking system, cost of equipment and expense of maintenance.

Table No. 25 shows the result of a test made with a car equipped with the ordinary spindle hand brake without gears, this being the same car that was used in the test of the Sterling brake, with the same equipment, brake leverage, shoes, etc. This test was made for the purpose of comparison as to the efficiency of the ordinary brake, such as is in use on the majority of cars now operated in the State, and one of the improved brakes. The comparison was made with the Sterling brake for the reason that the change from the Sterling brake to the ordinary spindle hand brake could be made more conveniently than with any other. The result shown in this table, computed under the same formula as was used in the case of the trial brake tests, would give the ordinary spindle brake an average stop of 67.01 feet and a percentage standing of 42.80. No sand was used in the test of this brake. The trial test of the Sterling brake, omitting the stops made with sand, gives an average stop of 63.79 feet and a percentage standing of 46.08.

As shown by Tables 26 and 27, experimental tests were made to ascertain the comparative amount of energy exerted by a motorman in stopping a car equipped with the Sterling brake and one equipped with the ordinary spindle brake, without gears. To make this test the ordinary brake handle was replaced by two brake wheels, each 18 inches in diameter, one of which was rigidly fastened to the spindle; over this a 4-inch collar was placed on the

spindle and on top of the collar the other wheel was placed, the wheel being loose on the spindle and free to revolve. Between the two a scales was fastened, the motorman exerting the power on the loose wheel through the scales to the wheel fastened to the spindle, and by this means to the brake shoe. To read the maximum amount of power exerted, a finger was screwed on the dial of the scales, with sufficient friction to allow it to be moved, and to remain in the position to which it was moved. This was placed so that the pointer of the scales came in contact with it and moved it to the position of maximum power indicated by the pointer, where it remained.

The average of all stops made by the Sterling brake with this equipment was 58.73 feet, and the average of the power applied was 77.08 pounds. With the ordinary spindle brake, the average stop was made in 56.87 feet, and the average power applied was 92.5 pounds. The tables show that in the test on the car equipped with the Sterling brake, with wheels in place of brake handle, on the stops at 15 miles an hour, the car traveled farther after the stop signal was given than it did on the following stops at 16 miles per hour. This would appear to be an error, but it is not, as the mortorman made three poor stops at this rate of speed. Even with these long stops at 15 miles an hour, the average stop for the two brakes is about the same, while the average of power applied with the Sterling brake is 77.08 pounds against 92.5 pounds on the ordinary spindle brake. Unfortunately, the poor stops which were made with the Sterling brake at 15 miles per hour, impair the value of the comparison between the two brakes. But the test is valuable in showing that the maximum amount of power exerted on the brake wheel, with the ordinary spindle brake, was 105 pounds, and the minimum was 85 pounds, and with the Sterling brake the maximum was 85 pounds and the minimum 65 pounds. The diameter of the hand wheels was 18 inches, while the sweep of the ordinary brake handle used is from 12 to 14 inches.

The amount of power which a motorman must exert in bringing a car to a standstill has quite a bearing on accidents which occur on electric roads, considering the number of times every day a motorman is obliged to exert this amount of energy on the handle of the brake; and it is not strange that he sometimes takes chances, which would likely not be the case with an easy means of controlling the car.

Table 28 shows the result of three stops, made at 15 miles per hour, with a car equipped with the Electric Selector and Signal Company's electric brake on rails that had just been flooded. This test on the wet rail was made for the purpose of comparison with results obtained with the same car and same equipment on a dry rail. The rails were wet by running a sprinkling cart over them three times and the result shows that the average stop on the wet rail was 71.73 feet and on the dry rail 60 feet. The reason for making this test and comparison was, that some of the railroad officials in this State do not consider it necessary to equip open cars, which are operated only in the summer season, with sand boxes, it being their theory that a car can be stopped as easily on a clean wet rail as on a dry one.

A letter, dated April 4, 1900, was sent to each of the contestants in the brake test, requesting them to furnish an approximate price for which they would sell their brakes complete in ten-car lots, free on board, at their factory. The following list shows the result of the answers to this request. As stated above, these prices are only approximate:

The Peckham Motor, Truck and Wheel Company.....	$125
The J. G. Brill Company	85
The Standard Air Brake Company.....	350
M. H. Vogel	30
The Sterling Supply and Manufacturing Company.....	35
The Devlin Street Car Brake Company.....	100
J. E. Reyburn	175
Price, Darling & Co.	200
The Electric Selector and Signal Company.....	160

The Sauvage Street Car Brake Company	$100
The G. P. Magann Air Brake Company	200
The General Electric Company	585
The Christensen Engineering Company	350

Respectfully submitted,

C. R. BARNES,
Electrical Expert.

CONCLUSIONS OF THE BOARD OF RAILROAD COMMISSIONERS.

To the Public:

The Board has devoted much time to this test; and, while nothing has been brought forth that will revolutionize the manner of stopping a car, the opportunity is afforded to present to railway officials and to the public facts and figures showing what the best appliances known to-day can do in the matter of stopping a car quickly. While these results are very satisfactory, there is still room for much improvement, and the Board feels that its action in holding a public test will result in still further improvements in brakes or in new inventions which will reduce the distance within which a car can now be stopped; and it has the satisfaction of knowing that it has done all in its power to bring about the adoption of better brakes than those now used by the majority of roads in this State, and thus reduce the number of accidents.

In this State there are several classes of electric roads all using the same motive power, applied in the same manner; but, as far as liability to accidents in their operation is concerned, they are as separate and distinct as steam and electric roads. There are roads operated in the smaller cities with single-truck cars, weighing from six to eight tons, at a maximum speed of from fifteen to eighteen miles per hour. The suburban roads, between the smaller towns and between the smaller cities and summer resorts,

operate the same class of cars, on which it is the custom, during summer holidays and on special occasions, to use trailer cars. In the larger cities double-truck cars, weighing from ten to seventeen tons, are operated at a maximum speed of twenty-five miles per hour. On some suburban roads, connecting large cities and extending from these cities to summer resorts, double-truck cars, weighing twenty-three tons and equipped for a maximum speed of fifty miles per hour, are operated. A brake which would fulfill all the conditions of safety for the smaller cars, operated at the lower rates of speed, might be entirely inadequate for controlling the heavier cars, operated at higher speed.

In the report of the electrical expert is given a list of the brakes in their order of standing, as a result of the actual mechanical test. This standing is based only on the result of the curves taken on the test and the skidding of wheels as noted at that time. This standing, however, is modified by adding to or deducting from it points of merit or demerit based on the following features of the brakes:

First.— Reliability and simplicity of system.
Second.— Liability of brakes to act when they should not.
Third.— Ease of operation by the ordinary motorman.
Fourth.— The cost of the equipment and maintenance.

After carefully considering these various points in each system, and adding to or taking from the mechanical standing of the different brakes, as given in the report of the electrical expert, the Board gives the several brakes the following final standing in the order of their respective merit:

The Electric Selector and Signal Company.
The Peckham Motor, Truck and Wheel Company.
The Sterling Supply and Manufacturing Company.
The G. P. Magann Air Brake Company.
M. H. Vogel.
The Devlin Street Car Brake Company.
The J. G. Brill Company.
The Sauvage Street Car Brake Company.
The Standard Air Brake Company.

The Christensen Engineering Company.
The General Electric Company.
J. E. Reyburn.
The Columbia Car Light and Brake Co.
Price, Darling & Co.
The Safety Appliance Co.
Bach & Schlegel.

It is not the intention of the Board to recommend any particular brake for any class of service, leaving this selection to the judgment of the railroad officials themselves. The Board will, of course, exercise fully its power under the law, to require of companies the use of sufficient and safe equipment for the public service.

After a careful consideration of the whole subject of brakes for electric cars, the Board has determined that, except in special cases, where the liability to accident is very remote, the ordinary single chain and spindle hand brakes, now generally used, should be replaced by the brakes made by one of the following manufacturers, or any other, which, in the judgment of the Board, is hereafter shown to be equally efficient:

AIR BRAKES.

The G. P. Magann Air Brake Company.
The Standard Air Brake Company.
The Christensen Engineering Company.
J. E. Reyburn.

ELECTRIC BRAKES.

The Electric Selector and Signal Company.
The General Electric Company.

FRICTION BRAKES.

The Peckham Motor, Truck and Wheel Company.
The J. G. Brill Company.

HAND POWER BRAKES.

The Sterling Supply and Manufacturing Company.
M. H. Vogel.
The Sauvage Street Car Brake Company.